21450- Intake
RS-OH-W.H. Sammis

316 (b) DEMONSTRATION FOR THE W.H. SAMMIS GENERATING STATION

Prepared for

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I. INTRODUCTION

In accordance with requirements pursuant to the evaluation of adverse impact of cooling water intake structures on aquatic ecosystems under Section 316 (b), Public Law 92-500, this report has been prepared for submittal to the State of Ohio, Environmental Protection Agency. The results, conclusions and data are hereby submitted as support for a decision as to whether or not the cooling water intake system for W.H. Sammis Generating Station (Ohio Edison Company) represents best available technology for minimizing environmental impact while insuring the protection of a balanced indigenous biota in the site vicinity (Ohio River). This study report has been prepared in accordance with the U.S. Environmental Protection Agency draft guidelines for Section 316b evaluations[1] hereinafter called the "guidelines". It has been concluded that operation of the plant constitutes impacts which appear insignificant in regard to non-fish biotic categories specified in the guidelines and justification is presented in the 316a Demonstration Report for W.H. Sammis Station.[2] These conclusions are not presently at issue and this report will be confined to fish-related impacts.

It is generally conceded that potential adverse environmental impacts to aquatic ecosystems from power generation primarily involve the entrainment, impingement and subsequent mortality of fishes at intake structures. It is also evident that attempts to precisely evaluate losses due to plant impact on a quantitative population basis are generally unsuccessful or prohibitively expensive relative to potential results obtained. The determination of whether adverse environmental impacts exists generally involves a qualitative decision based on life history, ecology, abundance and contribution to ecosystem function of those species in which plant induced mortality can be documented, particularly if those species have sport and/or commercial significance. Resource management decisions based on realistic assessments of adverse impacts require that an adequate and sufficiently precise data base be obtained from which estimates of plant induced mortality to resident fish populations can be made. Once this determination is made, then all available ecological information can be brought to bear in assessing the significance of the apparent mortality.

III. PHYSICAL SETTING

The W.H. Sammis Plant is located on the Ohio River near Stratton, Jefferson County, Ohio at river mile 53.8. It is situated on the pool formed by the New Cumberland Lock & Dam approximately 1500 ft downstream. Sammis Station has seven coal fired steam electric generating units with a net demonstrated capability of 2392 MW. The once-through cooling water system has a maximum flow of 2,588 cfs (6.51 percent of mean; 40 percent of low river flow) with a maximum intake velocity of approximately 5.11 ft/sec. The intake structure extends slightly into the river at a depth of about 12 ft to 26.5 ft below the normal pool level (Figure 1).

Circulating water at the W.H. Sammis Plant enters the structure via three ports, each 16 ft wide and 14.5 ft high. A schematic of the intake structure appears in Figure 2. The intake ports empty into a duct which leads to a common forebay from which each circulating pump then draws. Maximum screen backwash flow is approximately 4,116 gpm. Screens are of the conventional design (vertical traveling) with 3/8" mesh size. Screens are operated sequentially on a continuous cycle and debris is discharged back into the river through a common pipe. Condenser water is discharged through three nozzles, 12 ft in diameter, 28.5 ft below normal pool elevation. The discharge is approximately 1300 ft downstream from the intake and exhibits a nominal mean ΔT of 19.2 °F.[2] An intake temperature profile for the year of sampling is shown in Figure 3.

Each of the seven (7) units have two screens and two circulating pumps. Each screen is made up of 60 segments which measure 10 ft by 2 ft, constructed of No. 10 screen wire cloth. All 14 screens operate at a depth of 28.5 ft in the intake chamber, and rotate at a speed of 10 fpm. The velocity of the water through the screens to Units 1-4 is 1.03 fps, for Units 5 and 6 it is 2.14 fps, and for Unit 7 it is 2.64 fps. When the screens start, an automatically operated solinoid valve opens and supplies river water from the house service pumps to wash debris from the screens. The screens are not connected to the automatic circuit controls which regulate their running time. Each traveling screen (2 per unit) on Units 1-4 are manually operated twice per shift for approximately 30 minutes per run, provided the circulating pumps

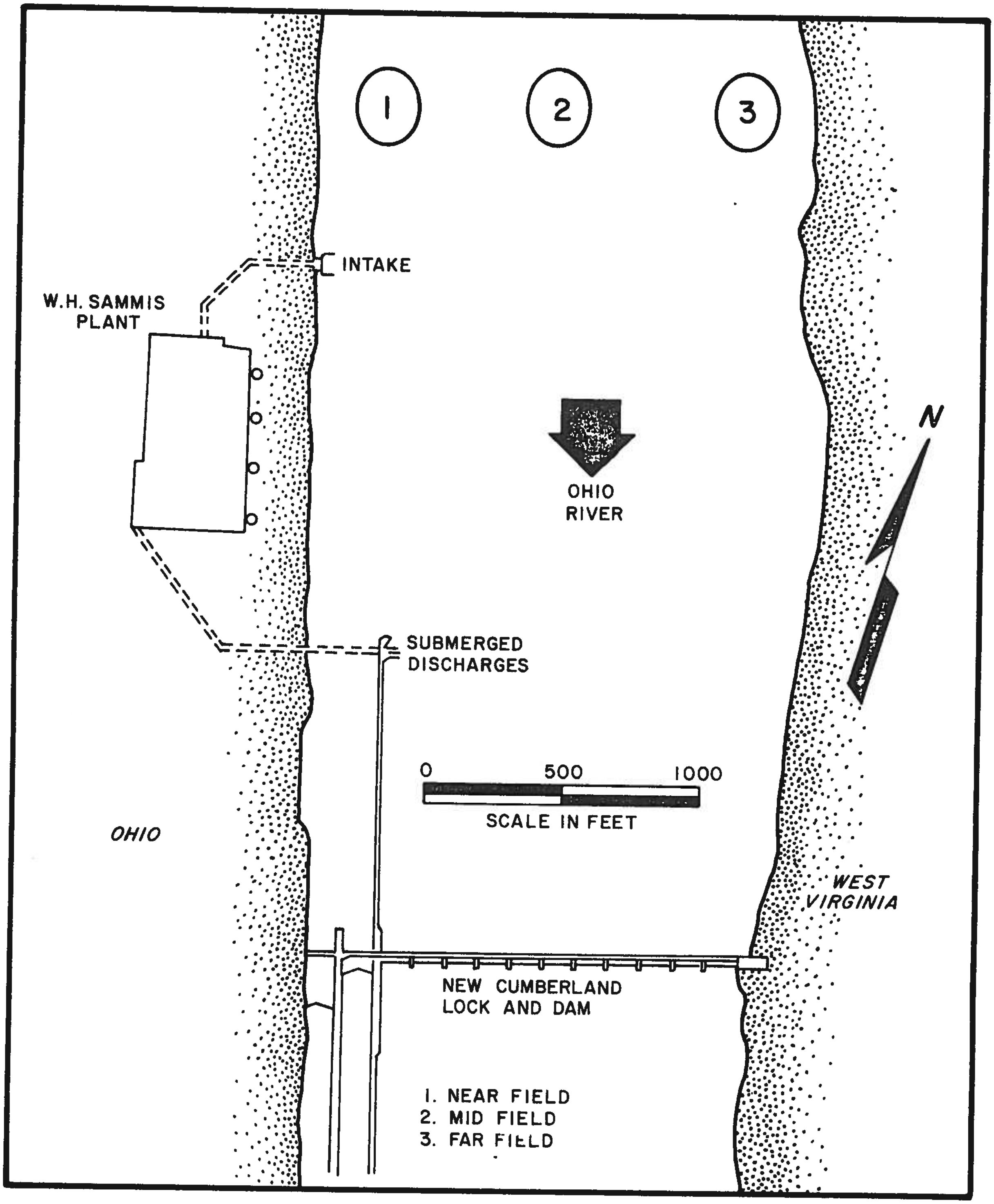

Figure 1. Sammis Station Location.

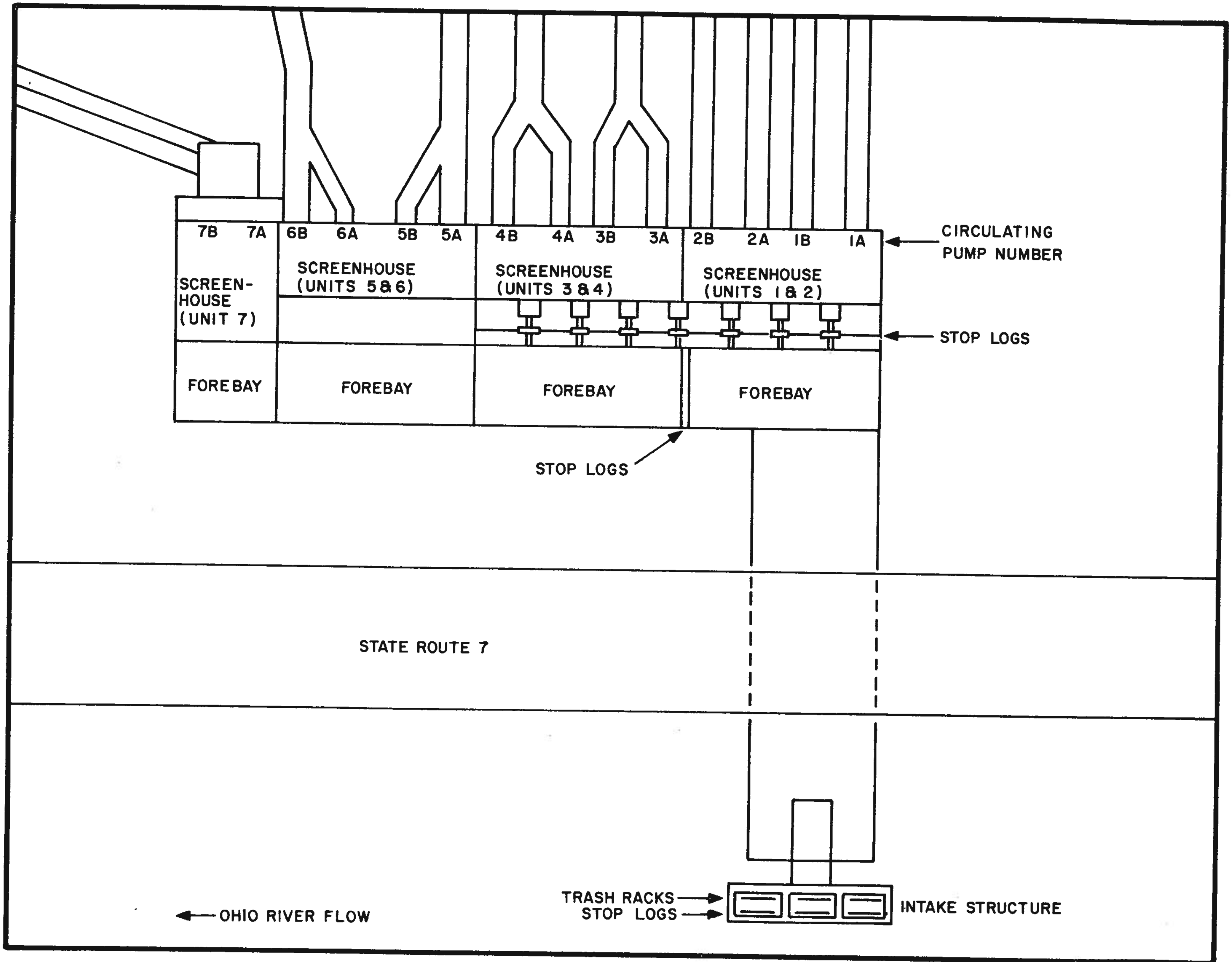

Figure 2. Sammis Station Intake-horizontal cross section.

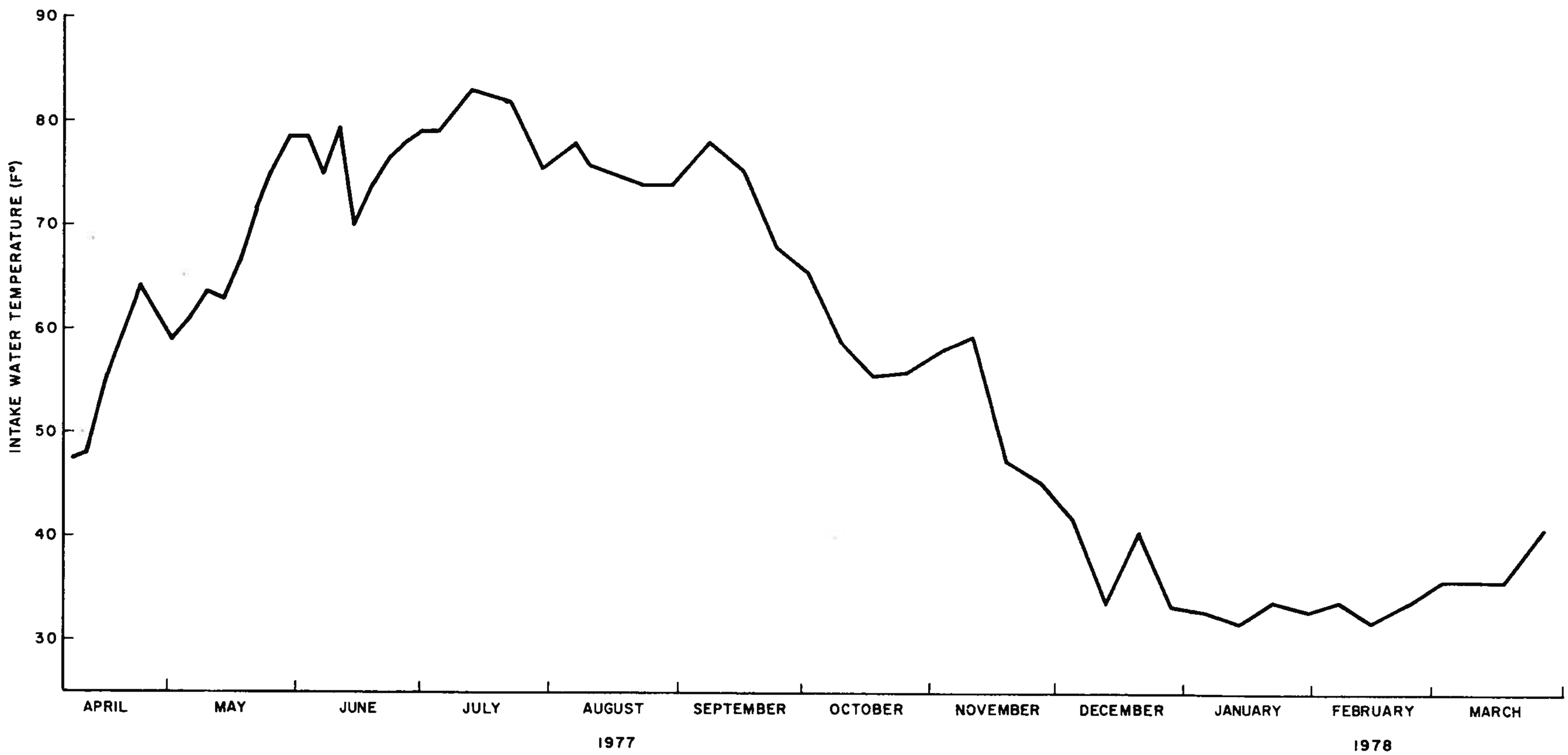

Figure 3. Intake temperature profile-Sammis Station, 1977-1978.

for those units are in operation. The traveling screens for Units 5-7 (2 per unit) run continuously when their respective circulating pumps are in operation. Maximum design circulating pump rates for each unit appear in Table 1.

Depths in this area of the river drop quickly from the shoreline to 30 or 40 ft near the center. Flow ranges from 6,500 cfs to approximately 350,000 cfs with a mean flow of 39,800 cfs. Flow during the study year from April 1977 to March 1978 ranged from 7,800 cfs to 177,000 cfs (Figure 4).

Two significant tributaries are located immediately upstream. One mile upstream on the West Virginia side is Tomlinson Run and on the Ohio side is Yellow Creek, situated about 3.5 miles upstream from Sammis Station (Figure 5).

The interested reader is referred to a more detailed treatment of the hydrology, historical flows, plant operating characteristics and water quality which has been reported elsewhere.[2]

Table 1
Maximum Design Circulating Pump Rates for Units 1 - 7
Sammis Station

Unit No.	One Pump Operation gpm	One Pump Operation m^3/hr	Two Pump Operation gpm	Two Pump Operation m^3/hr
1	62,000	14,080.2	93,000	21,120.3
2	62,000	14,080.2	93,000	21,120.3
3	62,000	14,080.2	93,000	21,120.3
4	62,000	14,080.2	93,000	21,120.3
5	117,700	26,729.7	148,000	33,610.8
6	197,600	44,875.0	285,000	64,723.5
7	251,500	57,115.6	356,400	80,938.4

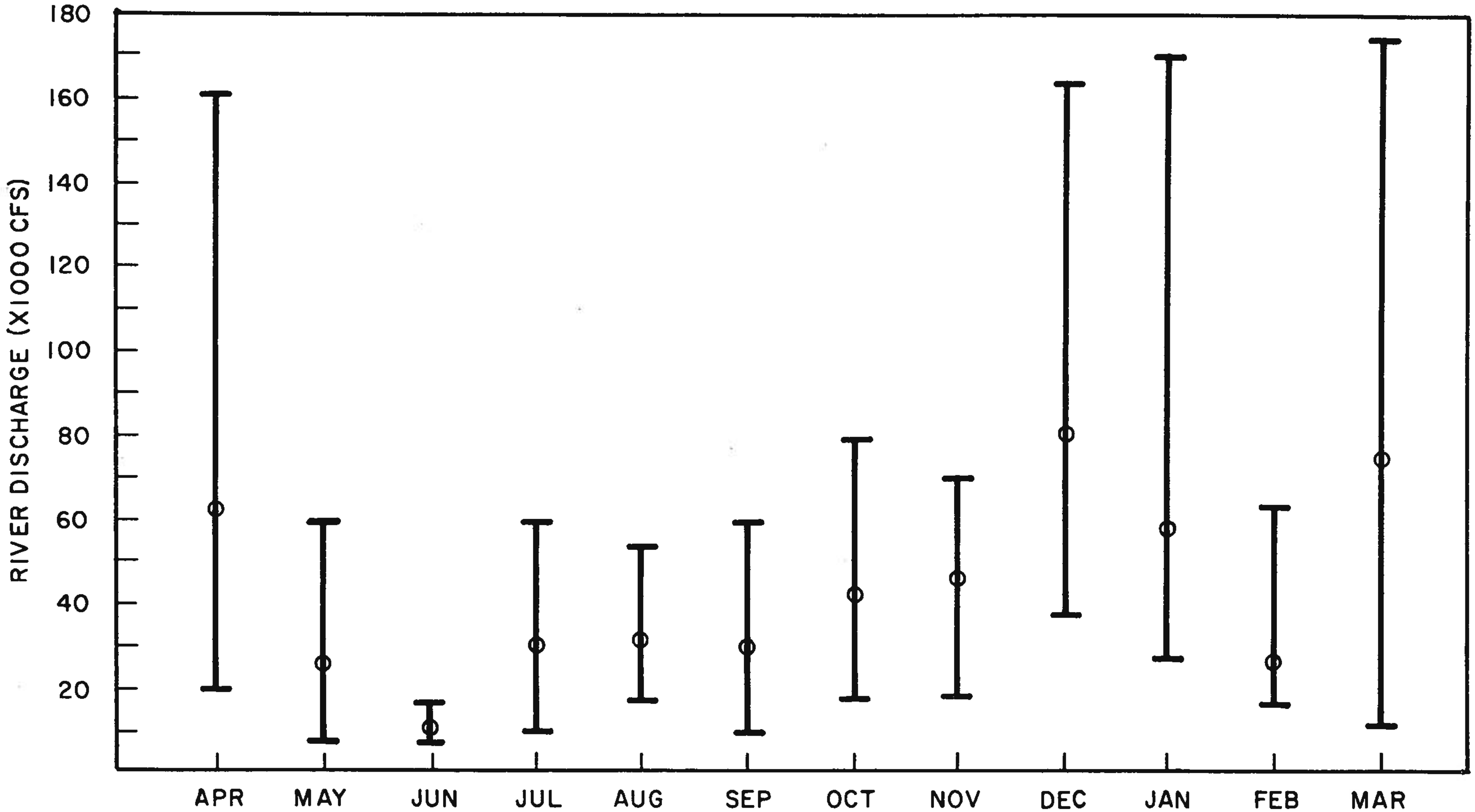

Figure 4. Ohio River flows for the study year, 1977-1978.

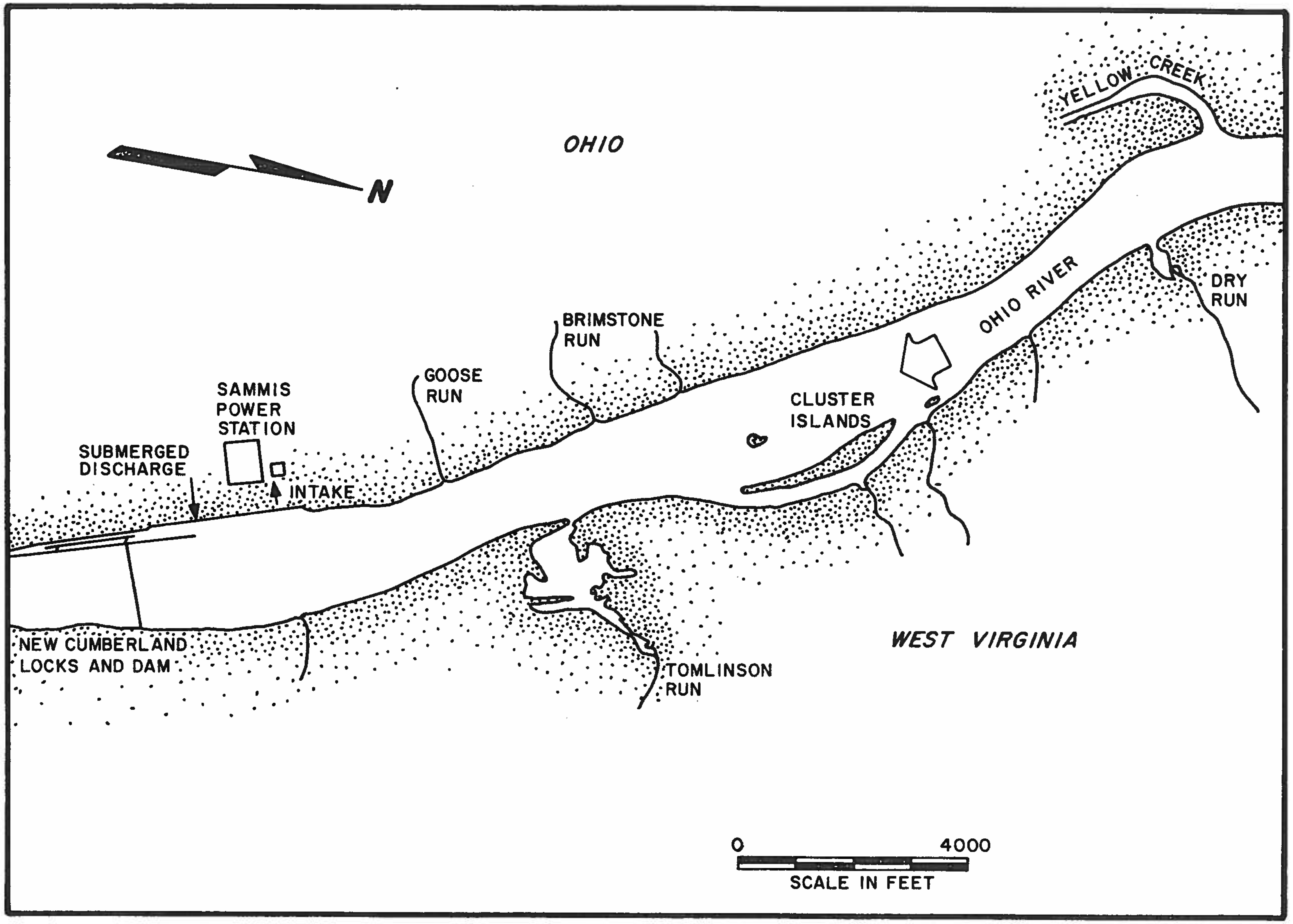

Figure 5. Tributaries of the Ohio River in the vicinity of the Sammis Station.

IV. METHODS AND MATERIALS

A. Entrainment

1. Sampling Strategy

The sampling strategy used here was based in part on the reproductive characteristics of species known to occur commonly in the Ohio River. The survey was designed to span the entire period of spawning for the more abundant species (e.g., shad, emerald shiner, drum). The sampling effort was concentrated in that time interval during which peaks of larval abundance were expected. Reproductive activity for most common river species usually takes place over a one to two month interval with a recognizable period of several weeks in which peak egg and larval abundances occur. On the basis of other studies (e.g., Meyers and Bremer[3]), about 8 days appears to be near the maximum time interval for which acceptably precise quantitative documentation of ichthyoplankton abundance and species composition can be made.

Ichthyoplankton generally exhibit highly clumped or patchy distributions and little is known about patch size or frequency of patch occurrence. Fish larvae are known to exhibit diel patterns of distribution and often more are entrained at night. In order to account for possible diel differences in abundance, a series of replicate day/night samples were taken. On each sampling date four collections were made, each of two hours duration. Approximately 100 m^3 of water was filtered during each collection. Two collections were taken sequentially between about 1200 to 1800 and constituted a daytime pair of samples. A similar pair of collections were taken between about 2100 to 0200, depending on time of sunset. Thus at least 8 hours of collecting were completed for each sampling date which resulted in about 400 m^3 of total sampled volume.

It has long been known that crepuscular periods can be times of high activity for fishes and an additional sampling interval of two hours duration was included which began one hour before sunrise and sunset. Crepuscular samples were taken every 8 days thereby adding 4 hours of sampling time to that day (and a total of 600 m^3 of sampled volume).

A schedule for each sampling date appears in Appendix A-1.

2. Sampling Techniques

Larval fish samples were collected directly from the cooling water intake system prior to passage through the condenser. This was done by tapping directly off of an overhead 18" line which passed through a large butterfly valve connected at a bend in the main condenser cooling line (Pump 6B). This flow then passed through an auxiliary 4" tap to which a short length of fire hose was attached. Cooling water from the short length of the hose was then filtered through a standard 0.5 m plankton net (505 μ mesh size) suspended in a 55-gallon drum which was set in a circular steel tank (radius and height of 2.5 feet). A 90° V-notch wier was inserted and sealed into a cutout section in the side of the tank.

Baffling material was set around the perimeter of the drum to reduce turbulence. This allowed for more accurate measurement of water level or head height (see Appendix A-3 for precision of measurement of head height). The height of the wier notch was located 13 ± .06" above the tank bottom and two ruled scales were attached to the sides of the wier, calibrated in inches. The water level was then read directly from the scale. Because of the difficulty in maintaining the tank absolutely level, readings were taken on both sides of the notch and if different, a mean of the two was entered as head height. Head height at equilibrium or constant flow was measured at the commencement of each individual sampling interval. In general, system pressure was maintained near constant for each sample and little fluctuation over a 4-hour period was usually noted.

The circulating water pump intakes are located in a straight line along a common forebay (see Figure 2). The forebay was an area of observed high turbulence and the circulating water pipe sampled just behind the circulating pump was one of the largest by volume of the operating units. The sampled volume was assumed then to be representative of that passing through the plant as a whole.

3. Source Water Samples

In order to provide perspective with regard to estimates of entrainment mortality at the plant, an evaluation of background densities of ichthyoplankton in the source water was included. Minimally, assessments of cross river variability in abundances as well as diel and vertical patterns of distributions were considered adequate to evaluate potential time/space variations in ichthyoplankton concentration in the vicinity. Accordingly, three stations (or sampling fields) were chosen along a line 500 ft upriver from the intake (Figure 1). Station 1 was considered representative of the near field and was expected to provide data indicative of larval concentrations passing through the plant. Stations 2 and 3 were chosen as representative of mid and far field conditions, respectively.

appear to all be mid channel habitats (see p. 24)

Once every 8th (or occasionally 4th) day and coinciding with in-plant entrainment sampling, source water collections were made. A standard 1 m circular plankton net (505 μ mesh) was towed for 5 minutes at the surface and near bottom in each of the sampling fields (1, 2, 3). Tows were made upriver and boat speed was adjusted to maintain a wire angle of approximately 45° for near bottom samples (ca 15-18 ft) using a 30 lb oceanographic depressor attached to the wire below the net. Surface tows were made with the net towed just below the surface approximately 75 ft astern and to one side of the vessel. One sample from both surface and near bottom, which constituted a "paired" sample for any given location, was taken during the day and the same procedure repeated at night, making a total of 12 individual tows for each 24-hour period (i.e., one surface and near bottom collection/day and night for 3 stations).

The plankton net was fitted with a General Oceanics flow meter inserted into the net mouth. Flow meters were factory calibrated prior to the commencement of the project. Flow was calculated from calibration curves provided by the manufacturer.

4. Preservation and Laboratory Methodology

Samples were preserved in 5 percent formalin solution and returned to the laboratory. Rose Bengal dye (1 percent strength) was added to facilitate sorting. Individuals were scored as being in one of two size classes at sorting (i.e., greater or less than 10 mm). Fish larvae were identified to the lowest positive identifiable taxon (usually species) that the condition of the specimen would allow and both larvae and eggs counted. Size ranges were obtained by selecting the largest and smallest specimen observed by cursory examination. These then were measured to the nearest mm fork length. Specimens which were abraded or otherwise severely damaged were counted and classified as unidentified.

5. Systematics

The references used as aids to identification are numbered 4-15 in the list of references for this report. The location and shape of the digestive tract, myomere number and melanophore pigment pattern were the major diagnostic characters used. Reference to species known to occur as adults in the Ohio River was often the basis for designation at the specific level. Several methods of quality control were used in relation to sorting and identification. A number of samples were re-examined at a later date for larvae potentially missed in the first sort. Sorting was generally highly efficient and few larvae were found after the first sort. The second sorting was discontinued after confirmation of high sorting efficiency.

Identifications were confirmed by having a second systematist check each new taxon reported as well as a random subsample of taxa previously identified. Finally, a size series of each taxon was sent to a recognized taxonomic expert for additional confirmation. The results of this analysis are on file with the contractor.

6. Calculations, Measures of Dispersion and Bias

Distributions of fish eggs and larvae in freshwater environments are characterized by high spatial and temporal variability. Larval densities are apparently subject to fluctuation from hour to hour and day to day. In essence this means that one is never sampling from stable distributions and therefore estimates of dispersion from sampling statistics reflect both sampling error and changes in real abundances. In the present survey, several measures of dispersion or variance were examined in order to determine the nature and degree of uncertainty (dispersion) associated with calculated annual entrainment.

The larval fish densities are presented as mean values for daytime and nighttime for each sampled date. Standard deviations were calculated and therefore each mean density has associated with it a confidence interval. From these, one can calculate an upper and lower bound for day or night entrainment for that day (Appendix B-2). Such confidence limits based on two samples are generally unrealistically broad. By sampling consecutively over a four-hour span one should considerably reduce the small scale spatial heterogeneity often associated with net sampling. By assuming distributions constant over the sampling period (four hours) each 2-hour sample represents an estimate of the mean concentration over that period. The standard error of the mean for the replicated samples was then used as a more realistic measure of dispersion. For all samples in which larval densities exceeded 0.5 individuals/m^3, standard errors ranged from one to about 84 percent of the mean (Appendix B-2). Many were less than 20 percent; this is a low between-sample dispersion for ichthyoplankton and indicative of the potential reduction of small scale spatial heterogeneity in this sampling mode.

To indicate the effect of dispersion on estimated larval densities, a maximum density was calculated based on an upper bound as defined by the standard error (SE) for all cases SE>0.1. A total maximum density for that date was then arrived at by summing the maximum daytime and nighttime densities (Appendix B-2). If one assumes that the probability of obtaining any single maximum density equal to 0.5 (a conservative assumption) then the probability of obtaining any two maxima is 0.25 or one in four. The probability of obtaining 12 maxima for the 6 highest daily densities recorded assuming a probability of occurrence of 0.5 for any individual maximum is .0024. If these conditions were to occur, the resulting entrainment would exceed the mean estimate by an amount here defined as the "maximum upper bound" of the estimate. An upper bound for total estimated entrainment based on this figure can be considered a conservative estimate (i.e., the true value is likely to be less) of maximum error based on the present data base and can serve as a reasonable maximum upper bound to the estimate.

Total annual entrainment was calculated by first determining the number of hours (in 24) of day and night for each sampling day. This was obtained by calculating the number of hours between sunrise and sunset for the sampling date. A circadian (24 hour) day was then constructed which was defined as follows: day = # hours from 1 hour after sunrise to 1 hour before sunset; night = # hours from one hour after sunset to 1 hour before sunrise; crepuscular = 1 hour before to 1 hour after sunrise and sunset. These hours were then assumed constant for all days in the sampling interval (usually 4 days). For each time period the volume of water passing through the plant during that interval was multiplied by the mean density for that interval. The schedule of pumped volume was then assumed constant for the interval. For those dates in which crepuscular samples were not taken, the density observed at night was used for the crepuscular period as the two periods were shown not to be statistically different. Crepuscular densities can be markedly different from daylight densities however. Values for total larvae entrained for each interval are summed to obtain an estimate of annual entrainment.

There are several sources of error and bias (there are probably others) which enter the estimate and their effects are difficult to evaluate. Conditions are assumed constant over an interval (which certainly is not the case) and occasionally large differences between consecutive sampling dates occur either by reason of markedly altered larval densities, plant load factors affecting pump rates, or both.

Errors in calculating volume filtered from the wier data (Appendix A-3) were estimated to be about 10 percent with a slight bias toward overestimation of volume flow due to the non-linearity of the relationship between head height and flow in 90° V-notched wiers. At high volume flows, as often observed at Sammis, this error would be approximately 15 percent. Similar errors of potentially larger magnitude can occur with estimates based on flow meter data (or the plankton nets). In general flow meter readings exhibited reasonably low variability between samples with occasional anomalously low estimates of volume filtered.

B. Impingement

1. Sampling Strategy

Previous studies of fish impingement at the W.H. Sammis Plant indicate that impingement appears to exhibit seasonality and considerable variability while catch rates can exceed 1,000 individuals in a 24-hour period. While the species composition was not determined, several general observations from studies conducted at power plants on the Ohio River are relevant to study design. At any given site, few species contribute significantly to impingement (often only one or two). Small individuals, usually young-of-the-year, make up the bulk of the catch and rates of impingement often exhibit periodic peaks in which large numbers of individuals may be taken in a short period of time. The herrings (gizzard shad, skipjack herring) are particularly vulnerable and can be expected to contribute significantly to the catch. White bass, carp, and yellow perch may also occasionally occur in moderate numbers. Game species (e.g., walleyes, basses) are in general rarely caught on intake screens although crappies and sunfish appear to be more vulnerable than others in this category.

An adequate estimate of impingement involves sampling at sufficiently frequent intervals such that the probability of encountering large periodically occurring screen wash catches is high. This allows for the determination of the duration and frequency of appearance of episodes of high impingement. The sampling interval used was made compatible with entrainment and collections were made every eight days for one year (Appendix A-1).

2. Sampling Techniques, Methodology and Systematics

The screen wash at the W.H. Sammis Plant discharges into a common trough which discharges directly into the river. The wash cycle is continuous and in order to obtain a sample of organisms impinged on the screens, the flow had to be diverted into a large basket which was constructed by Ohio Edison personnel for that purpose. The accumulation of debris and subsequent overflow in the collecting basket was such that a continuous 24-hour sample could not be taken. Consequently, the 24-hour day was subdivided by 3-hour periods and a single collection of one hour's duration was taken during each period (i.e., one sample every 3 hours for a 24-hour period). The total 24-hour impingement was estimated by extrapolation (i.e., multiplying total catch by 3).

Fish and other macronekton were identified, enumerated and subsamples measured and weighed. At least 400 individuals of dominant species were weighed and all size classes were sampled. Length-weight regressions were calculated and these appear in Appendix C-1. Also recorded in Appendix C-3 are the number of fish weighed and measured, the total subsample weight and number of fishes counted.

Fish were generally identified, weighed and measured on location. Vouchers and doubtful specimens were placed in 10 percent formalin and returned to the laboratory. Identifications generally follow Trautman.[13]

Calculations of annual impingement were made with the assumption that catch rates remain constant during each sampling interval. When impingement rates are low as observed here, such an assumption appears valid for purposes of general assessment. As observed rates of impingement vary during any 24-hour period, calculations of confidence limits or other dispersion statistics are difficult to interpret. Day to day variability is likely significant and no dispersion statistics were calculated.

The results can best be interpreted as a "best estimate" of mean annual impingement. Comparison with past estimates were made to provide a basis for evaluation of year to year variability.

V. RESULTS AND DISCUSSION

A. Entrainment

It is estimated that slightly in excess of 17 million larvae were entrained at the Sammis Plant in 1977 with a maximum upper bound as defined of about 21.4 million larvae (Appendix B-1 and B-2). A complete list of species identified, volume filtered and larval density for each sampling date is presented in Appendix B-3. A number of factors contribute to variability and therefore uncertainty in the calculation and interpretation of observed rates of entrainment. The calculated value is a function of both observed density and pumped volume for the sampled year. Both of these parameters need be evaluated in relation to within year variability and more importantly to the "mean" year, an average of historical conditions.

Concerning density, an attempt was made to reduce variability due to small scale spatial heterogeneity by sampling relatively large volumes over long periods of time. In general larval densities were quite low at Sammis Plant and it was difficult to evaluate variability for the most part. For the few weeks in which densities exceeded .1 larvae per m^3, standard deviations were less than the mean, suggestive of reduction in the effects of small scale patchiness on observed values. The consistently low densities observed over much of the season tended to reduce uncertainties due to both between interval and intra-day variation. The observed rates can be considered reasonably accurate estimates of actual density for the sampled day as well as for the interval between sampling. As with most studies of this kind, the distribution of larvae was characterized by a severely restricted number of samples exhibiting relatively high densities. These occurred during the period 25 May to 14 June (Table 2). Even during these periods, densities were generally less than $0.5/m^3$. These rates were maintained for about 3 sampling intervals. Failure to sample during any one of these intervals would have had little impact on the overall estimate.

Concerning circulating pump rates, the units at Sammis are very different with regard to capacity (see Table 1). For instance, unit 7 uses approximately four times the

Table 2

Mean Larval Densities Per m^3 for Sammis Plant Entrainment and Source Water Collections

Date	In-Plant			Source Water					
				1		2		3	
	D	C	N	D	N	D	N	D	N
4/27/77	.01		.01						
5/1/77	0	.004	.004						
5/9/77	.02	.01	.01	0	.02	.004	.02	0	0
5/13/77	0		.02						
5/17/77	0	.01	.01						
5/21/77	.02		03						
5/25/77	.02	.12	.05						
5/29/77	.04		.31	.64	.41	1.04	.44	.36	.45
6/2/77	.19	.12	.17	.18	.37	.21	.18	.20	.23
6/6/77	.17		.18						
6/10/77	.01	.05	.05	.01	.09	.10	.22	.11	.06
6/18/77	.01	.003	.01	.05	.30	.02	.11	.05	.07
6/22/77	.02		.04						
6/26/77	.003	.01	.05						
6/30/77	.01		.02						
7/4/77	.02	.01	.03	.06	.06	.08	.09	.53	.06
7/12/77	.003	.02	.01						
7/21/77	.01	.05	.04	.44	.50	.07	.01	.32	.05
7/29/77	.01	.01	0						
8/7/77	.01	0	.003	0	.01	0	.01	0	.01
8/14/77	.02	0	0						
8/22/77	0	0	0	0	0	0	.01	0	0

D - Day C - Crepuscular N - Night

hourly volume as unit 1 and one time unit of operation for unit 7 would equal the combined capacity of units 1-4. Daily pump rates can, therefore, differ markedly between sampling dates (a variation exceeding .7 x $10^6 m^3$/day was observed). For instance, the density of larvae on 18 June and 6 August was approximately .013/m^3 during the day. The total estimated entrainment was approximately 25 percent less on 6 August because of differences in pumped volume and length of daylight. For the sampled year, however, variability from differences in pump volume are generally less than 25 percent and estimated daily volumes are correlated with density. In comparing the sampled year with other years, the effect of differential yearly pump rates can introduce considerable bias. Table 3 lists the number of hours various units at Sammis were connected to load for the 4 years previous to this year. As can be seen during 1977, plant load was about 22 percent less than the "mean" (adjusted for pump volume) year. Using the same observed densities but adjusting to the mean year increases the annual estimate by approximately 4 million larvae or about 24 percent.

Relating larval densities to the "mean" year is more difficult, however, since in-plant data from other years is not available. Previous studies (Westinghouse 316a[2]) and ichthyoplankton surveys taken during the same year in the source water (Wapora 1977[16]) indicate that the immediate vicinity of the Sammis Plant is not an area of high spawning intensity and that in general low densities are observed (<0.5/m^3). Year to year variation is not likely to significantly affect annual rates (i.e., densities are always low) assuming these observations are typical of "mean" conditions.

There are a number of other patterns and attendant conclusions in the data set which are important in evaluation and interpretation of power plant entrainment. The efficacy of in-plant sampling techniques is particularly illustrated here and is important to the estimation and evaluation of entrainment at Sammis. The first is that in-plant samples do produce excellent results comparable to that observed using other sampling devices and are superior in most respects to other methods. Considering the spatial/temporal and gear differences, the near field source water samples were excellent predictors of ichthyoplankton densities observed in the plant. Using the whole data set, the near field and in-plant samples could not be statistically differentiated though the test used was not one of high sensitivity (Table 4).

Table 3

A History of Hours Connected to Load Per Unit
(April - August) - Sammis Station

Year	Unit 1	2	3	4	5	6	7
1973	3232.7	1970.0	3480.2	3517.4	2943.1	3099.9	2405.8
1974	3272.2	3449.3	3332.5	3307.3	3267.0	907.6	1302.2
1975	2988.2	3020.7	2529.4	2866.0	1632.6	2605.7	2056.1
1976	2953.1	3128.6	2412.6	2945.4	2050.7	1997.4	1372.9
1977	3164.0	2346.3	0	3176.0	120.0	952.3	2894.8
Mean (1973-76)	3111.6	2892.2	2938.7	3159.0	2473.4	2152.7	1784.3
Difference (1977-Mean)	+52.4	-545.9	-2938.7	+17.0	-2353.4	-1200.4	+1110.6
Relative Pump Factor	1.0	1.0	1.0	1.0	1.6	3.0	4.0
Weighted Difference	-52.4	-545.9	-2938.7	+17.0	-3765.4	-3601.2	+4442.2

TOTAL WEIGHTED DIFFERENCE (1977-Mean) = -6444.4 hr
TOTAL WEIGHTED MEAN = 29,654.2 hr
PERCENT DIFFERENCE (1977 vs. Mean) = -22%

Table 4

Larval Fish Statistical Comparisons
Sammis Station

Wilcoxon's Signed Rank Test - Entrainment and Source Water

Test	p	Conclusion
In-plant = night field source water	NS	no difference
Day = night*	.05	night density higher
Day = crepuscular*	NS	no difference
Crepuscular = night*	NS	no difference

* In-plant densities only NS - Not Significant

The in-plant densities were often less than those in near field source water but high variability in the latter made statistical inference difficult. Near field densities were good predictors of in-plant densities (i.e., 3/4 of the time estimates were within one standard deviation) but the low densities and high variability observed did not provide an adequate test.

The patterns of distribution and abundance of ichthyofauna in this reach of the Ohio River are considerably different than those observed at other riverine and more particularly lake or reservoir sites. Larval densities are extremely low and only a single observation exceeded one individual per m^3. In most cases densities were less than $.5/m^3$ even during times of peak abundance. The species composition was almost wholly dominated by the family Cyprinidae: carp and minnows of the genus Notropis and Pimephales (Table 5). Abundant species such as shad and skipjack herring or sports fish like yellow perch, walleyed pike or sunfishes were rarely taken in larval samples. There was a statistically significant difference between day and night densities with the latter slightly higher on average. Crepuscular periods could not be distinguished from day or night and were assumed typical of night densities for purposes of calculation. The suppression of day/night differences is markedly different from observations in other environments where nighttime densities can be an order of magnitude higher. Positional or cross river differences could not be detected nor could surface to near bottom variation in larval abundance. Each station across the river was variably high or low and occasional isolated larger catches could be seen, perhaps an effect of small scale patchiness. Observed catch rates for source water were often higher than the observed in-plant but whether this reflects real differences in abundance and/or small scale patchiness cannot be determined from the present data base (Figure 6).

Seasonality of spawning activity also exhibits an unusual pattern. There appears to be a single spawning maxima of several weeks duration after which abundances fall to relatively low values. A possible secondary "peak" is suggested by the source water data in July but this was not observed in-plant. The onset of spawning activity occurs rapidly when water temperatures reach 70°F. Water temperatures warmed quite rapidly (Figure 3) in the spring and this effect on spawning as compared

Entrainment.

Table 5

Larval Fish Species List, Relative Rank and Percent of Total Catch - Sammis Station

Scientific Name	Common Name	Rank	Percent
Cyprinidae spp.	Carp-minnow	1	24.6
Pimephales notatus	Bluntnose minnow	2	11.8
Notropis atherinoides	Emerald shiner	3	8.5
Cyprinus carpio-Carassius auratus	Carp-goldfish	4	7.6
Notropis volucellus	Mimic shiner	5	4.5
Perca flavescens	Yellow perch	6	2.5
Notropis spilopterus	Spotfin shiner	7	2.2
Etheostoma sp.	Darter sp.	8	2.2
Stizostedion vitreum vitreum	Walleye	9	1.8
Ictalurus punctatus	Channel catfish	10	1.6
Dorosoma cepedianum	Gizzard shad	11	1.3
Catostomus commersoni	White sucker	12	1.1
Notropis sp.	Shiner sp.	13	1.1
Percina caprodes	Log perch	14	0.7
Noturus flavus	Stonecat	15	0.7
Lepomis sp.	Sunfish sp.	16	0.7
Centrarchidae spp.	Sunfishes	17	0.7
Ictalurus natalis	Yellow bullhead	18	0.4
Morone chrysops	White bass	19	0.4
Pomoxis sp.	Crappie sp.	20	0.4
Percidae sp.	Perch	21	0.2
Micropterus dolomieui	Smallmouth bass	22	0.2
Pomoxis annularis	White crappie	23	0.2
Unidentified*		24	24.6
			100.0

* Damaged

Ent. Total = 17362208 (from Lohner)
p. 46
* % = ent.

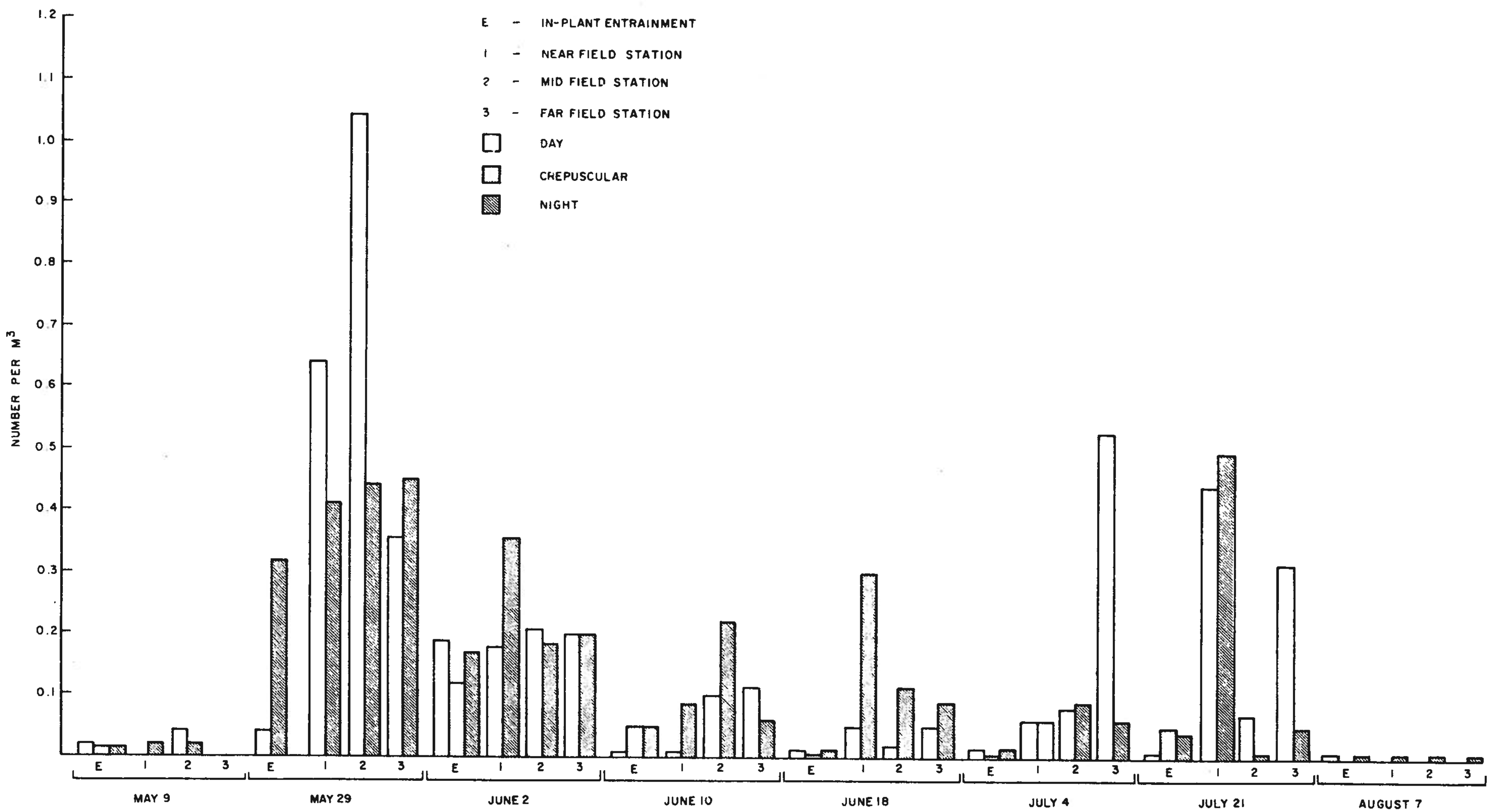

Figure 6. Larval fish densities for in-plant and source water samples - Sammis Station.

to other years may be significant. All species were represented in the early spawning with little evidence of successive "waves" of spawning activity as the season progressed. More extended spawning activity is indicated for emerald shiner which was taken later in the season. The abundance of larvae fall precipitously after 21 July and they were not vulnerable to the sampling gear or the plant after that time.

Size distribution of larvae taken from both in-plant and source water samples is revealing. Reference to Appendix B-4 and B-5 indicates that virtually no fewer larvae greater than 10 mm were taken at any time. This type of pattern has never been observed by Geo-Marine, Inc. at any power plant we have studied and may provide some explanation for the observed results. Diel effects are generally most pronounced when larger individuals dominate the catch and diel variation was greatly reduced. The absence of larger individuals in both source and plant intake water is likely due to their absence rather than due to gear bias but this cannot be completely ruled out. In general volume filtered by plankton nets was often 1/2 that observed for similar length tows in other waters and the slower absolute speed may increase net avoidance. Similar avoidance at the plant would also have to be postulated, however. Larger individuals (>10 mm) are taken regularly both with plankton nets and in-plant at other sites, supporting evidence for a hypothesis of low abundance of larger larvae in mid-channel habitats at Sammis. The data indicating rapid disappearance of larvae in July is again consistent with such a postulate. It is becoming apparent from studies on riverine environments (e.g., Conner[22]) that mid-channel habitats are not optimal for the larvae of most freshwater species and that larger post-larvae are usually found in nearshore or tributary habitats. The absence of shad and other abundant riverine ichthyoplankters suggests that in general riverine fishes either move rapidly out of mid-channel environments and/or suffer heavy mortality there with increasing larval size. The high abundance of the species as adults and juveniles at the Sammis Plant (see Table 7) are not inconsistent with a nearshore habitat hypothesis.

In summary, ichthyoplankton abundance is low at the Sammis Plant over the year. The observed onset of increased larval density occurred rapidly and the time of "peak" abundance extended from mid May to mid June. Fishes of the family Cyprinidae dominated the catch with many abundant riverine forms such as shad and drum absent or rarely taken. Diel and positional differences in abundance were not obvious and densities fell to near zero in late July. Only small individuals were taken in abundance and an hypothesis is advanced that ontogenetic changes in habitat selection occur at sizes less than 10 mm whereby larger larvae select nearshore or tributary habitats. Very few eggs were observed at any time.

B. Impingement

It is estimated that approximately 380,000 fish weighing some 10,881 lbs were impinged on the intake screens at Sammis Plant. The study results are summarized in Tables 6 and 7 and Appendix C-3. Over 90 percent of the total catch consisted of 3 species, and the gizzard shad alone comprised over 78 percent of the total or about 300,000 individuals. Most of the shad were collected during the fall and winter months when they appear to be attracted to thermal effluents. At other times shad were not abundant in the catch.

Seasonally, except for fall-winter, impingement rates were generally very low (<10 kgms/day). As young-of-the-year shad are recruited into the population at the end of summer their appearance in impingement samples increases. Periodic large impingements were generally not observed and sample to sample variability was low. Under or overestimates due to periodic but stochastically occurring impingement rates considerably above average are less likely to affect the annual estimates.

Both emerald shiner and channel catfish are commonly taken at all seasons with some increase when young-of-the-year are recruited in the fall. Carp dominate late summer catches while white bass are taken more often in the winter. Forty-two species were identified in the catch but most were rarely taken. No rare or endangered species that are on the Federal listing were observed. Five individuals of the Eastern banded killifish were collected during the survey and were returned live after being weighed and measured. This species appears on the Ohio Department of Natural Resources rare and endangered list. No other obvious patterns could be detected in the data.

Impinged

Projected #

Table 6

Annual Impingement Estimate - Sammis Station

Date		Survey Totals Number	Survey Totals Weight (Kg.)	Interval (days)	Annual Estimate Number	Annual Estimate Weight (Kg.)
April	7	264	3.684	8	2,112	29.5
	15	1,054	14.434	8	8,432	115.5
	23	300	7.866	8	2,400	62.9
May	1	297	9.315	8	2,376	74.5
	9	39	.465	8	312	3.7
	17	87	5.216	8	696	41.7
	25	204	2.633	8	1,632	21.1
June	2	192	3.540	8	1,536	28.3
	10	87	1.419	8	696	11.4
	18	177	3.333	8	1,416	26.7
	26	129	1.665	8	1,032	13.3
July	4	105	.729	8	840	5.8
	12	180	.660	8.5	1,530	118.8
	21	1,344	10.929	8.5	11,424	92.9
	29	540	7.641	8	4,320	61.1
August	6	291	3.396	8	2,328	27.2
	14	378	4.167	8	3,024	33.3
	22	681	7.158	7.5	5,108	53.7
	29	201	3.918	8	1,608	31.3
September	7	363	6.831	8	2,904	54.6
	15	330	12.525	8	2,640	100.2
	23	1,500	23.808	8	12,000	190.5
October	1	1,188	11.258	8	9,504	90.1
	9	2,544	34.983	8	20,352	279.9
	17	1,878	21.390	8	15,024	171.1
	25	339	2.687	8	2,712	21.5
November	1	22,569	68.674	8	180,552	549.4
	10	813	10.758	8.5	6,910	91.4
	18	2,355	38.870	8	18,840	311.0
	26	1,038	34.503	8	8,304	276.0
December	4	573	6.785	8	4,584	54.3
	12	3,600	132.466	8	28,800	1,059.7
	20	81	3.484	8	648	27.9
	28	117	8.580	8	936	68.6
January	5	63	5.546	8	504	44.4
	13	126	14.363	8	1,008	114.9
	21	75	5.781	8.5	638	49.1
	30	102	8.764	8	816	70.1

Table 6 (cont'd)

Annual Impingement Estimate - Sammis Station

Date	Survey Totals Number	Survey Totals Weight (Kg.)	Interval (days)	Annual Estimate Number	Annual Estimate Weight (Kg.)
February 6	120	7.429	7.5	900	55.7
14	66	4.397	8.5	561	37.4
23	63	4.930	8	504	39.4
March 2	198	14.924	7.5	1,485	111.9
10	66	6.130	7.5	495	46.0
17	519	12.905	8.5	4,412	109.7
27	228	8.063	8	1,938	68.5
			TOTAL	380,793	4,946.0

Table 7

Impingement, Species List, Percent Composition
and Estimated Annual Number Impinged - Sammis Station

Scientific Name	Common Name	Rank	Percent	# Impinged	% x Total
Dorosoma cepedianum	Gizzard shad	1	78.9	298,688	299005
Notropis atherinoides	Emerald shiner	2	9.5	36,104	36,002
Ictalurus punctatus	Channel catfish	3	3.0	11,384	11,369
Cyprinus carpio	Carp	4	2.5	9,528	94742
Morone chrysops	White bass	5	1.8	6,656	6821
Pomoxis annularis	White crappie	6	0.7	2,736	2652
	Crayfish	7	0.6	2,352	2273
Lepomis macrochirus	Bluegill	8	0.5	1,720	
Alosa chrysochloris	Skipjack herring	9	0.4	1,560	
Pimephales notatus	Bluntnose minnow	10	0.3	992	
Perca flavescens	Yellow perch	11	0.2	832	
Notropis spilopterus	Spotfin shiner	12	0.2	720	
Pomoxis nigromaculatus	Black crappie	13	0.2	600	
Lepomis sp.	Sunfish sp.	14	0.2	600	758 26% eir
Micropterus salmoides	Largemouth bass	15	0.2	576	
Ictalurus melas	Black bullhead	16	0.1	504	
Percopsis omiscomaycus	Trout perch	17	0.1	328	
Notemigonus crysoleucas	Golden shiner	18	0.1	320	
Notropis volucellus	Mimic shiner	19	0.1	312	
Percina caprodes	Log perch	20	0.1	288	
Moxostoma erythrurum	Golden redhorse	21	0.1	240	
Carassius auratus	Goldfish	22	0.1	240	
Lepomis gibbosus	Pumpkinseed	23	0.1 100%	240	
Carpiodes cyprinus	Quillback	24	<0.1	377,520	
Lepomis gulosus	Warmouth	25	<0.1		
Catostomus commersoni	White sucker	26	<0.1		
Fundulus diaphanus	E. banded killifish	27	<0.1		
Ictalurus furcatus	Blue catfish	28	<0.1		
Lepomis cyanellus	Green sunfish	29	<0.1		
Ambloplites rupestris	Rock bass	30	<0.1		
Moxostoma macrolepidotum	Shorthead redhorse	31	<0.1		
Stizostedion vitreum vitreum	Walleye pike	32	<0.1		
Salmo gairdneri	Rainbow trout	33	<0.1		
Hypentelium nigricans	N. hogsucker	34	<0.1		
Lepomis megalotis	Longear sunfish	35	<0.1		
Ictalurus natalis	Yellow bullhead	36	<0.1		
Stizostedion canadense	Sauger	37	<0.1		
Ictalurus nebulosus	Brown bullhead	38	<0.1		
Micropterus punctatus	Spotted bass	39	<0.1		
Notropis cornutus	Common shiner	40	<0.1		
Noturus sp.	Madtom sp.	41	<0.1		
Micropterus dolomieui	Smallmouth bass	42	<0.1		
Moxostoma carinatum	River redhorse	43	<0.1		
Esox masquinongy	Muskellunge	44	<0.1		
Catostomus sp.	Sucker sp.	45	<0.1		
Aplodinotus grunniens	Freshwater drum	46	<0.1		
				378,968	

In comparing species composition from impingement samples with those of entrainment there are major differences. Many more species are taken on the screens than were present in the ichthyoplankton. While emerald shiner was abundant in all samples, gizzard shad was rare in the ichthyoplankton. Carp, mimic shiner and bluntnose minnow were dominant in the plankton yet were only modestly abundant in impingement samples. Species which are vulnerable to entrainment at a given site then may not be particularly vulnerable to impingement and vice versa.

Length frequency distributions (Appendix C-2) indicate that most individuals were young-of-the-year or in age class I. This is the general pattern observed at power plants with which Geo-Marine, Inc. is familiar.

VI. ENVIRONMENTAL IMPACT

A. Plant Induced Mortality

As made clear in the guidelines, the essential element in a successful 316 demonstration is the quality of the data base relevant to the issues of environmental concern at the proposed plant site. It is necessary to be able to characterize the aquatic ecosystem in the area of expected impact and relate this to actual or potential effects by the proposed cooling system. The guidelines further state that "regulatory agencies should clearly recognize that some level of intake damage can be acceptable if that damage represents a minimization of impact". The definition of "minimization" generally involves a subjective judgement by the administrator having jurisdiction as to whether unacceptable changes or impacts on aquatic environments are being caused by the intake structure.

The estimation of impact is a speculative endeavor at best, particularly when background data are sparse. A number of assumptions of undetermined reliability need be made and the evaluation process requires careful consideration of site specific environmental information. In the present instance an extensive informational base is available for the site.

First, considering plant induced mortality to local fish populations from entrainment of ichthyoplankton, it is assumed that the estimates made here are "typical" of the sampled year and that in general local fish populations are in a "quasi" steady state (i.e., vary around some mean population size which is not radically different from that observed here). While ichthyoplankton concentrations do vary, adult populations often remain relatively stable from year to year. In the case of the Ohio River, a number of species may have been increasing in abundance over the last several decades.[17]

For purposes of later discussion it will be assumed that 100 percent of the entrained organisms will be killed. This is often not the case and numerous studies at power plants indicate that somewhat less than 100 percent are killed (e.g., Jensen[18]). The yearly entrainment at the Sammis Plant is estimated to be about 17 million larvae. If 50 to 75 percent are killed, the total estimated mortality would range from 9 to 13 million larvae. Considerable mechanical damage to ichthyoplankton could be detected in the in-plant samples as opposed to those caught in the plankton net. This appeared to be both size and species specific and a similar pattern has been observed by Geo-Marine, Inc. at other power plants. This would indicate that pump-induced mortality is occurring and that an assumed mortality of 50 percent or greater is a reasonable assumption in the absence of additional information.

Of the six most abundant species entrained, only the channel catfish and possibly the white bass are of commercial importance; the other species are considered forage species. All of the six most abundant forms have large populations in the Ohio River. The larvae are variably planktonic, must suffer high rates of natural mortality and thus populations appear to be highly resistant to "predation" (i.e., removal by power plant). Such populations can be expected to exhibit density-dependent mortality or "compensation" whereby removal of an individual has a positive effect on the survival of those individuals of that age class which remain.

There appear then to be density dependent or compensatory mechanisms in fish populations whereby the mean survival rate of those surviving a period of high mortality is increased, thus "compensating" for increased mortality from whatever source. The nature and degree of density dependent compensation involved in the regulation of fish populations are areas currently receiving much research emphasis and about which little information exists for the populations involved here. Some as yet undocumented compensation can be expected to occur in local populations of species vulnerable to impingement and entrainment. This partially accounts for the general inability of biologists to detect large changes in local populations after power plant operation (see Van Winkle for discussion of compensation[19]).

The area of impact or degree of vulnerability with distance from the plant for various species is extremely difficult to predict accurately. The source water samples indicate that the abundance of larvae in the Sammis area is quite low in comparison to other reaches of the river (e.g., Wapora[16], Geo-Marine, Inc.[20]) and that no cross river differences in abundance could be detected. The individuals which are entrained are primarily small (10 mm) prolarvae and are therefore likely to have been spawned within several miles upriver of the plant. The plant used some 11 percent of the flow passing the intake structure in June and while the plant may entrain a somewhat lower number per unit volume than appear in the source water, it can be estimated that at least 10 percent of the larvae passing the plant site are entrained.

Additional perspective is provided by assigning a conservative age specific natural mortality to the dominant species, then advancing the "cohort" to an adult size, here defined as age II. This then allows one to evaluate entrainment mortality in terms of "equivalent adults" or the number of adults which would be removed if no "compensation" were to occur for that year. It will be assumed that compensation does occur in succeeding years as the numbers of larvae and, therefore, entrainment are assumed in "steady state". In all cases less than 6000 "equivalent adults" are removed. Table 8 is a biological value-potential impact matrix for entrainment mortality in accordance with the guidelines while Table 9 lists the mean fecundity per female of common Ohio River species as well as the number of females required to produce 15 million eggs. The numbers for all species in terms of equivalent adults are not large.

The small size classes of larvae entrained at Sammis are those which appear to suffer the greatest natural mortality and therefore have the highest probability of being resistant to predation effects of the power plant. The larger size classes of larvae do not appear vulnerable and one could speculate that mid-river habitats are generally suboptimal for most riverine forms.[21,22] Those species being entrained remain abundant in the area (e.g., see entrainment) and indeed are much more numerous than might be predicted by larval densities alone. The cyprinids are not commercial forms and the impact from operation of the Sammis Plant cannot be seen to "adversely" affect the maintenance of present populations levels in the local environment.

Table 8

Biological Value-Potential Impact Matrix for Ichthyoplankton Entrainment

Species	Percent Total	Larval Entrainment	Survival to Adult (at 0.1%)	Value Grade
Shiner-minnow	52.9	9.18×10^6	9.18×10^3	III
Carp-goldfish	7.6	1.32×10^6	1.32×10^3	II
Walleye	1.8	0.31×10^6	0.31×10^3	I
Channel catfish	1.6	0.28×10^6	0.28×10^3	I
Other	36.1	6.27×10^6	6.27×10^3	II

Table 9

Mean Fecundity Per Female of Common Riverine Fish Taxa[13,23,24]

Species	Number of eggs ($\times 10^3$)	Number of Females per 20×10^6 eggs
Spottail shiner	.222-1.580	$13 - 90 \times 10^3$
Bluntnose minnow	.200-.500	$4 - 10 \times 10^3$
Yellow perch	23.0	869.6
Channel catfish	4.0-34.0	588.2 - 5000.0
White bass	125.0-600.0	33.3 - 160.0
Gizzard shad	300.0 (Age III)	66.7
Carp	350.0 (Age III)	57.1

Concerning impingement, an equivalent Age II fish impact matrix and associated survival rates are presented in Tables 10 and 11. As can be seen, the numbers of "equivalent adults" are not particularly high and it is difficult to envision the removal of this number as having detectable effects on local fish populations. There are several features of the screen wash system at Sammis which would appear to considerably reduce impingement mortality. First, the wash cycle is essentially continuous and impinged fishes do not long remain on the screens. This has been shown to greatly reduce impingement mortality to many fishes (see Jensen[18]). Fishes are returned directly to the river by current flow and few dead or floating fishes were ever seen in the vicinity of the discharge. A considerable percentage of impinged individuals are likely to survive under the observed conditions, reducing adverse impact accordingly.

B. Conclusions and Ecosystem Rationale

The determination of "adverse" impact involves subjective decisions in which the current or future ecosystem "state" must be evaluated against a background of multiple utilization of the resource (e.g., the Ohio River) by man. If the projected state is an acceptable one and will not be rendered unsatisfactory by a particular industrial use, then prudent resource management might dictate that the user was not causing unacceptable environmental impacts. Such judgements are beyond the scope of this report and can only be adequately addressed on a systemwide basis. They are nonetheless relevant to the problem of impact assessment at the Sammis Plant. It is clear that obvious or detrimental effects to local fish populations were not detected by this study. The conclusion is that impacts at the Sammis Plant are likely minimal in the sense of insuring the protection (maintenance at present levels) of the local fish fauna.

The area near the Sammis Plant does not appear optimal for larval fishes and it is difficult to envision that entrainment of the small number of individuals (ca 10 percent) passing the plant seriously affects the standing crops of locally very abundant minnows and carp. Likewise, the impingement rate is not particularly high and few fishes (comparable to a few good seine hauls) appear to be removed (mostly young-of-the-year). The screen wash system is well designed and in all probability reduces considerably mortality to impinged individuals.

Table 10

Estimation of Equivalent Age II Fish
Impinged Annually and Approximate Worth

Species	Age Class 0	I	II	Total	Use	Approximate Worth*
Gizzard shad	2852	256	4120	7228	-	-
Emerald shiner	48	2762	3603	6413	Bait	$ 267
Channel catfish	467	1670	306	2443	Food	$1222
Carp	713	51	2064	2828	-	-
White bass	617	29	-	588	Food	$ 294

*Assuming rates of $.50/lb for bait and $1.00/lb for the sale of fish for food

Table 11

Fish Survival Rate Factors*
From Larval, Age 0 and Age I Classes to Age Class II

Species	L	0	I
Gizzard shad	.001	.01	.4
Emerald shiner	.01	.1	.4
Channel catfish	.001	.1	.4
Carp	.001	.1	.4
White bass	.001	.1	.4

*Conservative estimates based on selective references.[18,19]
The actual survival rates are probably less.

It is concluded on the basis of the data reported here that significant adverse impacts to local fish populations from continued operation of Sammis Plant have not been shown.

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Appendix A

General

A-1 Survey Dates and Time Intervals - Sammis Station

A-2 Estimation of Flow Volume - Entrainment Sampling

A-3 Precision of Measurement of Head Height - Entrainment Sampling

A-4 Collection Losses or Anomalies - Sammis Station

Appendix A-1

Survey Dates and Time Intervals - Sammis Station

Date	Impingement (interval)	Entrainment (interval)	Source Water (interval)
7-8 April 1977	1710 - 1720	1630 - 0655 (D,N,C)	1627 - 1748 (D)
11-12 April 1977		1300 - 2330 (D,N)	
15-16 April 1977	1050 - 0900	1315 - 0715 (D,C,N,C)	
19-20 April 1977		1350 - 2354 (D,N)	
23-24 April	1235 - 1215	1310 - 0715 (D,C,N,C)	1707 - 1832 (D)
27-28 April 1977		1330 - 0052 (D,N)	
1-2 May 1977	1230 - 1030	1305 - 0730 (D,C,N,C)	
9-10 May 1977	1250 - 1050	1307 - 0715 (D,C,N,C)	1550 - 2306 (D,N)
13-14 May 1977		1315 - 0004 (D,N)	
17-18 May 1977	1234 - 1055	1300 - 0716 (D,C,N,C)	
21-22 May 1977		1407 - 0110 (D,N)	
25-26 May 1977	1312 - 1100	1330 - 0730 (D,C,N,C)	
29-30 May 1977		1450 - 0119 (D,N)	1510 - 2244 (D,N)
2-3 June 1977	1510 - 1610	1432 - 0730 (D,C,N,C)	1642 - 0324 (D,N)

D = Day N = Night C = Crepuscular

Appendix A-1

Survey Dates and Time Intervals - Sammis Station

Date	Impingement (interval)	Entrainment (interval)	Source Water (interval)
6-7 June 1977		1600 - 0145 (D,N)	
10-11 June 1977	1531 - 1345	1527 - 0655 (D,C,N,C)	1652 - 0112 (D,N)
18-19 June 1977	1517 - 1317	1553 - 0721 (D,C,N,C)	1701 - 2355 (D,N)
22-23 June 1977		1603 - 0155 (D,N)	
26-27 June	1512 - 0112	1512 - 0705 (D,C,N,C)	
30-31 June 1977		1525 - 0155 (D,N)	
4-5 July 1977	1343 - 1143	1350 - 0705 (D,C,N,C)	1454 - 2340 (D,N)
12-13 July 1977	1412 - 1212	1423 - 0700 (D,C,N,C)	
21-22 July 1977	1619 - 1719	1443 - 0645 (D,C,N,C)	1509 - 0030 (D,N)
29-30 July 1977	1425 - 1225	1415 - 0752 (D,C,N,C)	
6-7 August 1977	1440 - 1240	1453 - 0657 (D,C,N,C)	1442 - 2304 (D,N)
14-15 August 1977	1335 - 1135	1345 - 0638 (D,C,N,C)	
22-23 August 1977	1415 - 1215	1429 - 0640 (D,C,N,C)	1456 - 2242 (D,N)
29-30 August 1977	1126 - 0926	1300 - 0715 (D,C,N,C)	
7-8 September 1977	1125 - 0925		

D = Day N = Night C = Crepuscular

Appendix A-1

Survey Dates and Time Intervals - Sammis Station

Date	Impingement (interval)	Entrainment (interval)	Source Water (interval)
15-16 September 1977	0934 - 0734		
23-24 September 1977	1010 - 0810		
1-2 October 1977	0948 - 0748		
9-10 October 1977	1140 - 0940		
17-18 October 1977	1005 - 0805		
25-26 October 1977	1003 - 0735		
1-2 November 1977	1009 - 0853		
10-11 November 1977	1040 - 0840		
18-19 November 1977	0942 - 0745		
26-27 November 1977	0950 - 0745		
4-5 December 1977	1008 - 0808		
12-13 December 1977	1045 - 0845		
20-21 December 1977	1045 - 0845		
28-29 December 1977	1030 - 0830		
5-6 January 1978	1310 - 1110		
13-14 January 1978	1135 - 0935		
21-22 January 1978	1120 - 0920		
30 January 1978	1230 - 2310		
6-7 February 1978	1230 - 0745		
14-15 February 1978	1000 - 0800		
23-24 February 1978	1030 - 0730		

D = Day N = Night C = Crepuscular

Appendix A-1

Survey Dates and Time Intervals - Sammis Station

Date	Impingement (interval)	Entrainment (interval)	Source Water (interval)
2-3 March 1978	1150 - 0920		
10-11 March 1978	1030 - 0830		
18-19 March 1978	1030 - 0830		
26-27 March 1978	1200 - 0800		

D = Day N = Night C = Crepuscular

Appendix A-2
Estimation of Flow Volume

Method 1

Turn on system to maximum flow, then introduce flow to wier tank. With stopwatch, measure time from water introduction to first appearance of water over wier. For comparison to Method 2 the flow was calculated as follows:

Wier dimensions: R = 30", H = 13" (wier height)

Time to fill (Tf) = 1.3 min. 1 gal = 231 in^3, Volume (V) = πR^2 h/231 = 159 gal.

Vol. flow (gpm) = Tf x V = 1.3 x 159 = 122.3

This calculation was performed in order to reveal potential large scale design error. It is considered less accurate than the wier height measurement method.

Method 2

This method consists of allowing system to reach equilibrium then measuring the head height in inches above the wier notch. A mean height as measured on both sides of wier is recorded. Care must be taken to reduce water turbulence to assure accurate measurement of height. Wier should be placed such that it is very nearly level.

For comparison with Method 1, flow was calculated as follows:

Head height = H = .412 ft

For 90° V-notch wier, Barnes formula gives $Q = 2.48\ H^{2.48}$

where,

Q = flow in cfs

For H = .412 ft, Q = .275 cfs or 123.4 gpm

System pressure during test was 11.6 PSI.

Appendix A-3

Precision of Measurement of Head Height

To estimate precision of measurement of head height, a series of 32 measurements were taken during the course of study. Recordings were made at approximately one minute intervals in sets of six to eight measurements. For each set, a mean or average for that set was calculated and the absolute value of the difference between this mean and each associated measurement was listed. The "normalized" measurements were then tabulated and a standard deviation (S) based on all 32 measurements was calculated. An interval of twice the standard deviation was used in determining confidence intervals in regard to precision of measurement of head height.

For 32 measurements 2S = 0.212"; for a mean head height of 6.5", applying Barnes equation, the volume of water filtered during a 2-hour sampling period is 109.47 m^3. Applying a confidence interval of 0.212", one obtains 123.0 and 100.6 m^3 as the limits of precision or about ±10% of the calculated volume for the range of flows involved in this study.

Appendix A-4

Collection Losses or Anomolies - Sammis Station

Date	Collection	Remarks
4/7/77	Entrainment	Evening crepuscular not taken--initial pump start up was late enough to cause overlap with first crepuscular
4/7/77	Source Water	Night course not run--unfamiliarity with Yellow Creek channel at night
4/23/77	Source Water	Night samples not taken--net depressor lost; backup lost previous day at Edgewater
5/25/77	Source Water	Samples were collected on 29 May; boat under repair on 25th
6/10/77	Source Water	Mid-deep sample (daylight) lost; jar split in transit to Dallas
6/14/77	Entrainment	Samples not taken--pump down
6/18/77	Source Water	Near-deep and mid-surface samples (daylight) lost in shipping; jars developed leaks, dry when opened
10/25/77	Impingement	Sampling basket began to clog with leaves halfway through survey--total sampling was shortened to 6 hrs 34 min.
11/1/77	Impingement	Sampling basket clogged due to leaves during entire survey--each sample was broken into either two ~25 min. runs or one 50 min. run; total sampling time was shortened to 6 hrs. 13 min.
1/30/78	Impingement	Sample basket clogged due to leaves--samples broken into several runs equally one hour each; total sampling time shortened to 3 hrs. 40 min.

Appendix B

Entrainment

Appendix B-1

Annual Larval Entrainment Estimate - Sammis Station

Date		Density (#/m³)			Interval	Volume (m³) Pumped per interval			Larvae Entrained per interval			Total
		D	N	C		D	N	C	D	N	C	
April	7	0	0	0	4	-	-	-	0			
	11	0	0	-	4	-	-	-	0			
	15	0	0	0	4	-	-	-	0			
	19	0	0	-	4	-	-	-	0			
	23	0	0	0	4	-	-	-	0			
	27	.009	.013	-	4	8,834,328	9,558,956	-	79,508	124,268	-	203,776
May	1	0	.004	.004	4	-	10,406,572	*		41,628	-	41,628
	5	0	0	-	4	-	-	-	0	0	-	0
	9	.020	.010	.011	4	8,221,572	5,736,276	2,910,400	164,432	57,364	32,016	253,808
	13	0	.020	-	4	-	9,699,640	-	0	193,992	-	193,1992
	17	0	.010	.008	4	-	6,257,564	3,341,824		62,576	26,736	89,312
	21	.021	.028	-	4	9,031,904	8,410,740	-	189,672	235,500	-	425,172
	25	.024	.055	.122	4	9,741,260	5,915,520	3,095,464	233,792	325,352	377,648	936,792
	29	.036	.324	-	4	10,798,940	9,663,864	-	388,760	3,131,092	-	3,519,852
June	2	.187	.166	.123	4	11,114,736	6,157,584	3,454,464	2,078,456	1,022,160	424,900	3,525,516
	6	.166	.176	-	4	10,802,440	9,248,492	-	1,793,204	1,627,736	-	3,420,940
	10	.015	.053	.045	6	14,706,264	7,793,934	4,483,230	220,596	413,076	201,744	835,416
	14	NS	NS	-		-	-	-	NS	NS	-	NS
	18	.013	.013	.003	6	16,316,448	8,747,220	5,012,736	212,112	113,712	15,036	340,860
	22	.016	.041	-	4	11,235,644	9,491,140	-	179,772	389,136	-	568,908
	26	.003	.046	.006	4	11,105,732	6,053,948	3,454,464	33,316	278,480	20,728	332,524
	30	.006	.018	-	4	11,175,192	9,551,592	-	67,052	171,928	-	238,980
July	4	.023	.028	.007	6	15,360,570	7,987,860	4,726,860	353,292	223,662	33,090	610,044
	12	.003	.005	.016	8	21,568,840	11,785,256	6,556,472	64,704	58,928	104,904	228,536
	21	.008	.038	.046	8	21,993,952	12,654,712	7,011,288	175,944	480,880	322,520	819,344
	29	.008	0	.008	8	18,233,656	-	6,007,792	145,872	0	48,064	193,928
August	6	.013	.003	0	8	15,933,704	11,165,688	-	207,136	33,496	0	240,632
	14	.018	0	0	8	19,013,760	-	-	342,248	0	0	342,248
	22	0	0	0	8	-	-	-	0	0	0	
	29	0	0	0	8	-	-	-	0	0	0	
											TOTAL	17,362,208

D - Day N - Night C - Crepuscular NS - Not Sampled

Appendix B-2

Estimated Larval Densities by Interval[1] - Sammis Station

				Day	? Night	Crepuscular	Sum?
Date	CDI (±SE)	CNI (±SE)	CCI (±SE)	NDI (max.) (x 10^5)	NNI (max.) (x 10^5)	NCI (max.) (x 10^5)	TNI (max.) (x 10^5)
7 April	0	0	0	0	0	0	0
11 April	0	0	-	0	0	-	0
15 April	0	0	0	0	0	0	0
19 April	0	0	-	0	0	-	0
23 April	0	0	0	0	0	0	0
27 April	.009 (±.009)	.013 (±.013)	-	.80 (1.60)	1.24 (2.48)	-	2.04 (4.08)
1 May	0	.004 (±.004)	.004 (±.004)	-	.40 (.40)	[2]	.40 (.40)
5 May	0	0	-	0	0	-	0
9 May	.02 (±0)	.010 (±0)	.011 (±.004)	1.64 (1.64)	.56 (.56)	.32 (.44)	2.52 (2.64)
13 May	0	.020 (±0)	-	0	1.92 (1.92)	-	1.92 (1.92)
17 May	0	.010 (±0)	.008 (±.008)	0	.64 (.64)	.28 (.56)	.22 (1.20)
21 May	.021 (±.021)	.028 (±.022)	-	1.88 (3.76)	2.36 (4.20)	-	4.24 (7.96)
25 May	.024 (±.006)	.055 (±.035)	.122 (±.106)	2.32 (2.88)	3.24 (5.28)	3.76 (7.04)	9.36 (15.20)[3]
29 May	.036 (±.023)	.324 (±.013)	-	3.88 (6.36)	31.32 (32.56)	-	35.2 (38.92)[3]
2 June	.187 (±.054)	.166 (±.014)	.123 (±.042)	20.80 (26.80)	10.20 (11.08)	4.24 (5.68)	35.24 (43.56)[3]
6 June	.165 (±.055)	.176 (±.142)	-	17.92 (23.84)	16.24 (29.36)	-	34.20 (53.20)[3]

density * ~~[illegible]~~ volume (Table B-1)

Appendix B-2

Estimated Larval Densities by Interval[1] - Sammis Station

Date	CDI (±SE)	CNI (±SE)	CCI (±SE)	NDI (max.) (x 10^5)	NNI (max.) (x 10^5)	NCI (max.) (x 10^5)	TNI (max.) (x 10^5)
10 June	.015 (±.008)	.053 (±.008)	.045 (±.015)	2.22 (3.42)	4.14 (4.74)	1.98 (2.64)	8.34 (10.80)[3]
14 June	ND	ND	-		-	-	-
18 June	.013 (±.006)	.013 (±0)	.003 (±.003)	2.10 (3.06)	1.14 (1.14)	.12 (.24)	3.42 (4.32)
22 June	.016 (±.003)	.041 (±.010)	-	1.8 (2.12)	3.88 (4.84)	-	5.68 (6.96)[3]
26 June	.003 (±.003)	.046 (±.039)	.006 (±.006)	.32 (.64)	2.76 (5.08)	.20 (.40)	3.32 (6.12)
30 June	.006 (±.006)	.018 (±.006)	-	.68 (1.36)	1.72 (3.00)	-	2.40 (4.36)
4 July	.023 (±.004)	.028 (±.014)	.007 (±.007)	3.54 (4.14)	2.22 (3.36)	.30 (.60)	6.12 (8.10)
12 July	.003 (±.003)	.005 (±.005)	.016 (±.011)	.64 (1.28)	.56 (1.12)	.80 (1.76)	2.32 (4.16)
21 July	.008 (±.008)	.038 (±.016)	.046 (±.046)	1.76 (3.52)	4.80 (6.80)	3.20 (6.40)	8.16 (16.72)
29 July	.008 (±.008)	0	.008 (±.008)	1.44 (2.88)	0	.48 (.96)	1.92 (3.84)
6 August	.013 (±.003)	.003 (±.003)	0	2.08 (2.56)	.04 (.08)	-	2.40 (3.20)
14 August	.018 (±.012)	0	0	3.36 (5.60)	0	0	3.36 (5.60)
22 August	0	0	0	0	0	0	0
29 August	0	0	0	0	0	0	0

Appendix B-2

Estimated Larval Densities by Interval[1] - Sammis Station

[1] Definition of symbols used:

CDI = density of larvae during daytime for any interval (No./m^3)

CNI = density of larvae during nighttime for any interval (No./m^3)

CCI = density of larvae during crepuscular for any interval (No./m^3)

NDI = calculated number of larvae entrained during daytime for any interval (No./m^3)

NCI = calculated number of larvae entrained during nighttime for any interval (No./m^3)

TNI = total calculated number of larvae entrained during crepuscular for any interval (No./m^3)

[2] Calculated with nighttime flows

[3] Six largest densities used for calculation of upper bounds

Date	TNI ± SE ($x 10^5$)
25 May 1977	9.36 ± 5.84
29 May 1977	35.20 ± 3.72
2 June 1977	35.24 ± 8.32
6 June 1977	34.20 ± 19.00
10 June 1977	8.34 ± 2.46
22 June 1977	5.68 ± 1.28
	40.62

Upper Bound = 17,362,208 + 4,062,000

= 21,424,208 larvae

Appendix B-3

Larval Fish Summary - Sammis Station

Table 1--Larval Fish: Day-Night Entrainment

Table 2--Larval Fish: Crepuscular Entrainment

Table 3--Larval Fish: Source Water Sampling

Table 4--Fish Eggs: Day-Night Entrainment

Table 5--Fish Eggs: Crepuscular Entrainment

Table 6--Fish Eggs: Source Water Sampling

Table 7--Juvenile Fish: Day-Night Entrainment

Table 8--Juvenile Fish: Crepuscular Entrainment

Table 9--Juvenile Fish: Source Water Sampling

Table 1

Larval Fish: Day-Night Entrainment - Sammis Station
Numbers, Species Composition and Calcualted Density (no./m^3) by Sampling Date
($\bar{x}$ = mean, s = standard deviation)

Date	Species	Day #1	Day #2	Night #1	Night #2
4/7/77	Total #	0	0	0	0
	Amt. water filtered	123.5 m^3	90.6 m^3	132.7 m^3	110.4 m^3
4/11/77	Total #	0	0	0	0
	Amt. water filtered	110.4 m^3	110.4 m^3	132.7 m^3	132.7 m^3
4/15/77	Total #	0	0	0	0
	Amt. water filtered	138.7 m^3	132.7 m^3	132.7 m^3	132.7 m^3
4/19/77	Total #	0	0	0	0
	Amt. water filtered	110.4 m^3	110.4 m^3	115.8 m^3	115.8 m^3
4/23/77	Total #	0	0	0	0
	Amt. water filtered	95.3 m^3	121.3 m^3	115.8 m^3	121.3 m^3
4/27/77	<u>Stizostedion</u> <u>vitreum</u> <u>vitreum</u>	0	2 (.02)	0	3 (.03)
	Total #	0	2 (.02)	0	3 (.03)
	Amt. water filtered	110.4 m^3	110.4 m^3	115.8 m^3	115.8 m^3
		($\bar{x}$=.01, s=.01)		($\bar{x}$=.01, s=.02)	
5/1/77	<u>Stizostedion</u> <u>vitreum</u> <u>vitreum</u>	0	0	0	1 (.01)
	Total #	0	0	0	1 (.01)
	Amt. water filtered	100.2 m^3	121.3 m^3	121.3 m^3	121.3 m^3
				($\bar{x}$=.004, s=.01)	
5/5/77	Total #	0	0	0	0
	Amt. water filtered	121.3 m^3	121.3 m^3	132.7 m^3	132.7 m^3

Table 1

Larval Fish: Day-Night Entrainment - Sammis Station

Date	Species	Day #1	Day #2	Night #1	Night #2
5/9/77	*Stizostedion vitreum vitreum*	1 (.01)	0	0	0
	Catostomus commersoni	1 (.01)	1 (.01)	1 (.01)	0
	Etheostoma sp.	0	1 (.01)	0	0
	Percina caprodes	0	0	0	1 (.01)
	Total #	2 (.02)	2 (.02)	1 (.01)	1 (.01)
	Amt. water filtered	132.7 m^3	132.7 m^3	132.7 m^3	132.7 m^3
		($\bar{x}$=.02, s=.00)		($\bar{x}$=.01, s=.00)	
5/13/77	*Cyprinus carpio-Carassius auratus*	0	0	0	1 (.01)
	Perca flavescens	0	0	1 (.01)	0
	Percina caprodes	0	0	0	1 (.01)
	Cyprinidae	0	0	1 (.01)	0
	Total #	0	0	2 (.02)	2 (.02)
	Amt. water filtered	138.7 m^3	132.7 m^3	132.7 m^3	132.7 m^3
				($\bar{x}$=.02, s=.00)	
5/17/77	*Percina caprodes*	0	0	0	1 (.01)
	Cyprinidae	0	0	1 (.01)	0
	Total #	0	0	1 (.01)	1 (.01)
	Amt. water filtered	184.8 m^3	184.8 m^3	184.8 m^3	184.8 m^3
				($\bar{x}$=.01, s=.00)	
5/21/77	*Cyprinus carpio-Carassius auratus*	0	1 (.01)	2 (.01)	0
	Etheostoma sp.	0	0	0	1 (.01)
	Unidentified sp.	0	4 (.03)	6 (.04)	0
	Total #	0	5 (.04)	8 (.05)	1 (.01)
	Amt. water filtered	132.7 m^3	121.3 m^3	157.5 m^3	170.8 m^3
		($\bar{x}$=.02, s=.03)		($\bar{x}$=.03, s=.03)	

Table 1

Larval Fish: Day-Night Entrainment - Sammis Station

Date	Species	Day #1	Day #2	Night #1	Night #2
5/25/77	*Cyprinus carpio-Carassius auratus*	1 (.01)	1 (.01)	5 (.03)	1 (.01)
	Cyprinidae	2 (.01)	0	0	0
	Unidentified sp.	2 (.01)	2 (.01)	10 (.06)	2 (.01)
	Total #	5 (.03)	3 (.02)	15 (.09)	3 (.02)
	Amt. water filtered	164.1 m^3	170.8 m^3	170.8 m^3	177.7 m^3
		($\bar{x}$=.02, s=.01)		($\bar{x}$=.05, s=.05)	
5/29/77	Percidae	0	0	0	1 (.01)
	Cyprinus carpio-Carassius auratus	0	0	5 (.03)	9 (.06)
	Notropis atherinoides	0	0	1 (.01)	3 (.02)
	Notropis spilopterus	0	0	8 (.05)	0
	Notropis volucellus	0	0	2 (.01)	1 (.01)
	Pimephales notatus	0	0	12 (.08)	11 (.07)
	Cyprinidae	10 (.06)	0	1 (.01)	0
	Dorosoma cepedianum	0	0	1 (.01)	0
	Unidentified sp.	0	2 (.01)	19 (.12)	28 (.18)
	Total #	10 (.06)	2 (.01)	49 (.31)	53 (.34)
	Amt. water filtered	170.8 m^3	157.5 m^3	157.5 m^3	157.5 m^3
		($\bar{x}$=.04, s=.03)		($\bar{x}$=.32, s=.02)	
6/2/77	*Perca flavescens*	0	0	1 (.01)	0
	Cyprinus carpio-Carassius auratus	0	0	0	1 (.01)
	Notropis atherinoides	1 (.01)	1 (.01)	0	0
	Notropis spilopterus	0	1 (.01)	0	0
	Cyprinidae	0	0	25 (.15)	23 (.13)
	Dorosoma cepedianum	2 (.01)	3 (.02)	0	0

Table 1

Larval Fish: Day-Night Entrainment - Sammis Station

Date	Species	Day #1	Day #2	Night #1	Night #2
6/2/77 (cont'd)	*Pomoxis* sp.	2 (.01)	2 (.01)	0	0
	Lepomis sp.	0	2 (.01)	0	0
	Unidentified sp.	16 (.10)	29 (.18)	0	8 (.05)
	Total #	21 (.13)	38 (.24)	26 (.15)	32 (.18)
	Amt. water filtered	157.5 m^3	157.5 m^3	170.8 m^3	177.7 m^3
		($\bar{x}$=.19, s=.08)		($\bar{x}$=.17, s=.02)	
6/6/77	*Perca flavescens*	0	0	0	1 (.01)
	Notropis atherinoides	0	1 (.01)	3 (.02)	0
	Notropis volucellus	0	0	1 (.01)	0
	Pimephales notatus	8 (.06)	13 (.09)	11 (.08)	0
	Cyprinidae	7 (.05)	18 (.12)	30 (.21)	4 (.03)
	Centrarchidae	1 (.01)	0	1 (.01)	0
	Total #	16 (.11)	32 (.22)	46 (.32)	5 (.03)
	Amt. water filtered	144.8 m^3	144.8 m^3	144.8 m^3	144.8 m^3
		($\bar{x}$=.17, s=.08)		($\bar{x}$=.18, s=.20)	
6/10/77	*Cyprinus carpio*-*Carassius auratus*	0	0	1 (.01)	3 (.02)
	Notropis atherinoides	1 (.01)	3 (.02)	1 (.01)	3 (.02)
	Notropis volucellus	0	0	0	1 (.01)
	Cyprinidae	0	0	2 (.02)	0
	Ictalurus punctatus	0	0	2 (.02)	1 (.01)
	Total #	1 (.01)	3 (.02)	6 (.05)	8 (.06)
	Amt. water filtered	132.7 m^3	132.7 m^3	132.7 m^3	132.7 m^3
		($\bar{x}$=.02, s=.01)		($\bar{x}$=.05, s=.01)	
6/14/77	Total # / Amt. water filtered	NS	NS	NS	NS

NS - Not Sampled

Table 1

Larval Fish: Day-Night Entrainment - Sammis Station

Date	Species	Day #1	Day #2	Night #1	Night #2
6/18/77	Notropis spilopterus	0	0	0	1 (.01)
	Notropis volucellus	0	0	1 (.01)	0
	Pimephales notatus	0	0	1 (.01)	0
	Cyprinidae	1 (.01)	3 (.02)	0	0
	Micropterus dolomieui	0	0	0	1 (.01)
	Total #	1 (.01)	3 (.02)	2 (.01)	2 (.01)
	Amt. water filtered	157.5 m^3	157.5 m^3	157.5 m^3	157.5 m^3
		($\bar{x}$=.01, s=.01)		($\bar{x}$=.01, s=.00)	
6/22/77	Cyprinus carpio-Carassius auratus	0	0	0	1 (.01)
	Notropis atherinoides	1 (.01)	0	0	1 (.01)
	Notropis spilopterus	0	0	1 (.01)	0
	Pimephales notatus	1 (.01)	0	1 (.01)	1 (.01)
	Ictalurus punctatus	0	0	1 (.01)	3 (.02)
	Noturus flavus	0	0	1 (.01)	1 (.01)
	Centrarchidae	0	0	0	1 (.01)
	Lepomis sp.	0	0	1 (.01)	0
	Unidentified sp.	1 (.01)	2 (.01)	0	0
	Total #	3 (.02)	2 (.01)	5 (.03)	8 (.05)
	Amt. water filtered	157.5 m^3	157.5 m^3	157.5 m^3	157.5 m^3
		($\bar{x}$=.02, s=.00)		($\bar{x}$=.04, s=.01)	
6/26/77	Etheostoma sp.	0	0	1 (.01)	0
	Notropis volucellus	0	0	1 (.01)	1 (.01)
	Pimephales notatus	0	0	6 (.04)	0
	Cyprinidae	0	0	6 (.04)	0
	Unidentified sp.	0	1 (.01)	0	0
	Total #	0	1 (.01)	14 (.09)	1 (.01)
	Amt. water filtered	177.8 m^3	170.9 m^3	164.1 m^3	157.5 m^3
		($\bar{x}$=.003, s=.004)		($\bar{x}$=.05, s=.06)	

Table 1

Larval Fish: Day-Night Entrainment - Sammis Station

Date	Species	Day #1	Day #2	Night #1	Night #2
6/30/77	*Cyprinus carpio*-*Carassius auratus*	0	1 (.01)	0	0
	Notropis volucellus	0	0	1 (.01)	0
	Notropis sp.	0	0	1 (.01)	0
	Cyprinidae	0	1 (.01)	2 (.01)	1 (.01)
	Noturus flavus	0	0	0	1 (.01)
	Total #	0	2 (.01)	4 (.02)	2 (.01)
	Amt. water filtered	170.9 m^3	170.9 m^3	170.9 m^3	170.9 m^3
		($\bar{x}$=.01, s=.01)		($\bar{x}$=.02, s=.01)	
7/4/77	*Notropis atherinoides*	1 (.01)	1 (.01)	0	1 (.01)
	Notropis volucellus	0	0	1 (.01)	0
	Notropis sp.	0	1 (.01)	0	0
	Pimephales notatus	0	1 (.01)	0	0
	Cyprinidae	3 (.02)	0	5 (.03)	0
	Ictalurus natalis	0	0	0	1 (.01)
	Total #	4 (.03)	3 (.02)	6 (.04)	2 (.01)
	Amt. water filtered	144.8 m^3	157.5 m^3	144.8 m^3	144.8 m^3
		($\bar{x}$=.02, s=.01)		($\bar{x}$=.03, s=.02)	
7/12/77	*Notropis* sp.	0	1 (.01)	0	1 (.01)
	Pimephales notatus	0	0	0	1 (.01)
	Total #	0	1 (.01)	0	2 (.01)
	Amt. water filtered	184.9 m^3	184.9 m^3	192.1 m^3	184.9 m^3
		($\bar{x}$=.003, s=.004)		($\bar{x}$=.01, s=.01)	
7/21/77	*Perca flavescens*	0	0	1 (.01)	3 (.02)
	Notropis atherinoides	1 (.01)	0	4 (.02)	0
	Notropis volucellus	0	0	2 (.01)	0

Table 1

Larval Fish: Day-Night Entrainment - Sammis Station

Date	Species	Day #1	Day #2	Night #1	Night #2
7/21/77 (cont'd)	*Pimephales notatus*	0	0	0	1 (.01)
	Morone chrysops	1 (.01)	0	1 (.01)	0
	Pomoxis annularis	0	0	1 (.01)	0
	Lepomis sp.	0	0	1 (.01)	0
	Unidentified sp.	1 (.01)	0	0	0
	Total #	3 (.02)	0	10 (.05)	4 (.02)
	Amt. water filtered	184.9 m^3	184.9 m^3	184.9 m^3	184.9 m^3
		($\bar{x}$=.01, s=.01)		($\bar{x}$=.04, s=.02)	
7/29/77	*Perca flavescens*	0	1 (.01)	0	0
	Notropis volucellus	0	1 (.01)	0	0
	Total #	0	2 (.02)	0	0
	Amt. water filtered	144.8 m^3	127.0 m^3	121.3 m^3	121.3 m^3
		($\bar{x}$=.01, s=.01)			
8/7/77	*Perca flavescens*	0	0	1 (.01)	0
	Unidentified sp.	3 (.02)	0	0	0
	Total #	3 (.02)	2 (.02)	1 (.01)	0
	Amt. water filtered	199.5 m^3	199.5 m^3	199.5 m^3	199.5 m^3
		($\bar{x}$=.01, s=.01)		($\bar{x}$=.003, s=.004)	
8/14/77	*Notropis volucellus*	1 (.01)	1 (.01)	0	0
	Unidentified sp.	0	4 (.02)	0	0
	Total #	1 (.01)	5 (.03)	0	0
	Amt. water filtered	170.9 m^3	170.9 m^3	170.9 m^3	170.9 m^3
		($\bar{x}$=.02, s=.02)			

Table 1

Larval Fish: Day-Night Entrainment - Sammis Station

Date	Species	Day #1	Day #2	Night #1	Night #2
8/22/77	Total #	0	0	0	0
	Amt. water filtered	170.9 m^3	177.8 m^3	177.8 m^3	177.8 m^3
8/29/77	Total #	0	0	0	0
	Amt. water filtered	151.1 m^3	151.1 m^3	151.1 m^3	151.1 m^3

Table 2

Larval Fish: Crepuscular Entrainment - Sammis Station
Numbers, Species Composition and Calculated Density (no./m^3) by Sampling Date
($\bar{x}$ = mean, s = standard deviation)

Date	Species	Evening #1	Morning #2
4/7/77	Total #	**	**
	Amt. water filtered	**	**
4/15/77	Total #	0	0
	Amt. water filtered	132.7 m^3	132.7 m^3
4/23/77	Total #	0	0
	Amt. water filtered	100.2 m^3	121.3 m^3
5/1/77	_Stizostedion vitreum vitreum_	1 (.01)	0
	Total #	1 (.01)	0
	Amt. water filtered	121.3 m^3	121.3 m^3
		($\bar{x}$=.004, s=.01)	
5/9/77	_Catostomus commersoni_	0	2 (.02)
	Unidentified sp.	1 (.01)	0
	Total #	1 (.01)	2 (.02)
	Amt. water filtered	132.7 m^3	132.7 m^3
		($\bar{x}$=.01, s=.01)	
5/17/77	Castostomidae	1 (.01)	0
	Cyprinus carpio-Carassius auratus	1 (.01)	0
	Unidentified sp.	1 (.01)	0
	Total #	3 (.02)	0
	Amt. water filtered	184.8 m^3	184.8 m^3
		($\bar{x}$=.01, s=.01)	

Table 2

Larval Fish: Crepuscular Entrainment - Sammis Station

Date	Species	Evening #1	Morning #2
5/25/77	*Cyprinus carpio-Carassius auratus*	14 (.08)	0
	Notropis volucellus	5 (.03)	0
	Etheostoma sp.	1 (.01)	0
	Unidentified sp.	19 (.11)	3 (.02)
	Total #	39 (.23)	3 (.02)
	Amt. water filtered	170.8 m^3	184.8 m^3
		($\bar{x}$=.12, s=.15)	
6/2/77	*Etheostoma* sp.	1 (.01)	0
	Notropis atherinoides	1 (.01)	2 (.01)
	Notropis spilopterus	2 (.01)	0
	Notropis volucellus	0	1 (.01)
	Pimephales notatus	2 (.01)	1 (.01)
	Cyprinidae	14 (.09)	6 (.03)
	Unidentified sp.	7 (.04)	5 (.03)
	Total #	27 (.16)	15 (.08)
	Amt. water filtered	164.1 m^3	184.8 m^3
		($\bar{x}$=.12, s=.06)	
6/10/77	*Cyprinus carpio-Carassius auratus*	1 (.01)	0
	Notropis atherinoides	2 (.02)	1 (.01)
	Notropis volucellus	1 (.01)	0
	Pimephales notatus	3 (.02)	0
	Cyprinidae	0	1 (.01)
	Dorosoma cepedianum	0	2 (.02)
	Ictalurus punctatus	1 (.01)	0
	Total #	8 (.06)	4 (.03)
	Amt. water filtered	132.7 m^3	132.7 m^3
		($\bar{x}$=.05, s=.02)	

Table 2

Larval Fish: Crepuscular Entrainment - Sammis Station

Date	Species	Evening #1	Morning #2
6/18/77	Cyprinidae	1 (.01)	0
	Total #	1 (.01)	0
	Amt. water filtered	157.5 m^3	121.3 m^3
		($\bar{x}$=.003, s=.004)	
6/26/77	*Notropis atherinoides*	1 (.01)	0
	Ictalurus natalis	1 (.01)	0
	Total #	2 (.01)	0
	Amt. water filtered	157.5 m^3	157.5 m^3
		($\bar{x}$=.01, s=.01)	
7/4/77	*Notropis* sp.	0	2 (.01)
	Total #	0	2 (.01)
	Amt. water filtered	151.1 m^3	144.8 m^3
		($\bar{x}$=.01, s=.01)	
7/12/77	*Notropis atherinoides*	0	3 (.02)
	Notropis volucellus	0	1 (.01)
	Cyprinidae	1 (.01)	1 (.01)
	Total #	1 (.01)	5 (.03)
	Amt. water filtered	192.1 m^3	184.9 m^3
		($\bar{x}$=.02, s=.02)	
7/21/77	*Perca flavescens*	0	3 (.02)
	Notropis atherinoides	0	14 (.08)
	Total #	0	17 (.09)
	Amt. water filtered	184.9 m^3	184.9 m^3
		($\bar{x}$=.05, s=.07)	

Table 2

Larval Fish: Crepuscular Entrainment - Sammis Station

Date	Species	Evening #1	Morning #2
7/29/77	*Perca flavescens*	1 (.01)	0
	Notropis volucellus	1 (.01)	0
	Total #	2 (.02)	0
	Amt. water filtered	127.0 m^3	121.3 m^3
		($\bar{x}$=.01, s=.01)	
8/7/77	Total #	0	0
	Amt. water filtered	199.5 m^3	199.5 m^3
8/14/77	Total #	0	0
	Amt. water filtered	170.9 m^3	170.9 m^3
8/22/77	Total #	0	0
	Amt. water filtered	177.8 m^3	177.8 m^3
8/29/77	Total #	0	0
	Amt. water filtered	151.1 m^3	151.1 m^3

Table 3

Larval Fish: Source Water Sampling - Sammis Station
Numbers, Species Composition and Calculated Density (no./m^3) by Sampling Date
($\bar{x}$ = mean, s = standard deviation)

Date	Time	Species	#1	#2	#3
				Surface	
4/7/77	Day	Total #	0	0	0
		Amt. water filtered	78.4 m^3	54.9 m^3	NS
				Mid	
		Total #	0	0	0
		Amt. water filtered	NS	NS	NS
				Surface	
	Night	Total #	NS	NS	NS
		Amt. water filtered			
				Mid	
		Total #	NS	NS	NS
		Amt. water filtered			
				Surface	
4/23/77	Day	Total #	0	0	0
		Amt. water filtered	143.8 m^3	111.4 m^3	136.9 m^3
				Mid	
		Total #	0	0	0
		Amt. water filtered	179.5 m^3	230.3 m^3	232.9 m^3
				Surface	
	Night	Total #	NS	NS	NS
		Amt. water filtered			

NS - Not Sampled

Table 3

Larval Fish: Source Water Sampling - Sammis Station

Date	Time	Species	#1	#2	#3
				Mid	
4/23/77 (cont'd)	Night	Total #	NS	NS	NS
		Amt. water filtered			
				Surface	
5/9/77	Day	Total #	0	0	0
		Amt. water filtered	106.7 m^3	74.6 m^3	65.7 m^3
				Mid	
		Carpiodes carpio	0	1 (.01)	0
		Total #	0	1 (.01)	0
		Amt. water filtered	98.0 m^3	134.6 m^3	104.9 m^3
				($\bar{x}$=.004, s=.005)	
				Surface	
	Night	*Catostomus commersoni*	1 (.01)	0	0
		Percina caprodes	1 (.01)	0	0
		Carpiodes carpio	0	1 (.01)	0
		Total #	2 (.02)	1 (.01)	0
		Amt. water filtered	114.9 m^3	113.1 m^3	113.9 m^3
				Mid	
		Catostomus commersoni	3 (.03)	1 (.01)	0
		Perca flavescens	0	1 (.01)	0
		Total #	3 (.03)	2 (.02)	0
		Amt. water filtered	98.7 m^3	85.3 m^3	102.3 m^3
			($\bar{x}$=.02, s=.01)	($\bar{x}$=.02, s=.01)	

NS - Not Sampled

Table 3

Larval Fish: Source Water Sampling - Sammis Station

Date	Time	Species	#1	#2	#3
				Surface	
5/29/77	Day	Cyprinus carpio-Carassius auratus	1 (.02)	0	0
		Notropis atherinoides	4 (.06)	4 (.09)	12 (.26)
		Notropis volucellus	13 (.20)	9 (.20)	0
		Pimephales notatus	0	0	1 (.02)
		Cyprinidae	1 (.02)	0	2 (.04)
		Pomoxis sp.	0	0	2 (.04)
		Total #	19 (.29)	13 (.28)	17 (.37)
		Amt. water filtered	66.0 m^3	46.0 m^3	46.0 m^3
				Mid	
		Percidae	1 (.06)	0	0
		Notropis atherinoides	6 (.35)	25 (.72)	11 (.28)
		Notropis spilopterus	0	1 (.03)	1 (.03)
		Notropis volucellus	0	3 (.09)	0
		Pimephales notatus	0	1 (.03)	1 (.03)
		Cyprinidae	5 (.29)	8 (.23)	0
		Pomoxis sp.	1 (.06)	1 (.03)	0
		Lepomis sp.	0	0	1 (.03)
		Unidentified sp.	4 (.23)	23 (.66)	0
		Total #	17 (.99)	62 (1.79)	14 (.35)
		Amt. water filtered	17.2 m^3	34.6 m^3	39.9 m^3
			($\bar{x}$=.64, s=.50)	($\bar{x}$=1.04, s=1.01)	($\bar{x}$=.36, s=.01)
				Surface	
	Night	Percina sp.	0	1 (.02)	0
		Etheostoma sp.	0	1 (.02)	1
		Cyprinus carpio-Carassius auratus	2 (.03)	0	2 (.03)

Table 3

Larval Fish: Source Water Sampling - Sammis Station

Date	Time	Species	#1	#2	#3
5/29/77 (cont'd)	Night	*Notropis atherinoides*	12 (.15)	6 (.13)	15 (.21)
		Notropis spilopterus	8 (.10)	1 (.02)	6 (.08)
		Notropis volucellus	15 (.19)	7 (.15)	10 (.14)
		Pimephales notatus	1 (.01)	6 (.13)	8 (.11)
		Cyprinidae	0	2 (.04)	0
		Clupeidae	1 (.01)	0	0
		Pomoxis sp.	1 (.01)	0	0
		Lepomis sp.	0	0	2 (.03)
		Total #	40 (.51)	24 (.52)	46 (.63)
		Amt. water filtered	77.8 m^3	46.5 m^3	73.1 m^3
				Mid	
		Etheostoma sp.	3 (.06)	0	0
		Cyprinus carpio-*Carassius auratus*	3 (.06)	3 (.06)	0
		Notropis atherinoides	1 (.02)	3 (.06)	1 (.03)
		Notropis spilopterus	1 (.02)	0	0
		Notropis volucellus	2 (.04)	5 (.10)	3 (.08)
		Pimephales notatus	5 (.09)	3 (.06)	6 (.17)
		Cyprinidae	2 (.04)	3 (.06)	0
		Dorosoma cepedianum	0	1 (.02)	0
		Total #	17 (.31)	18 (.36)	10 (.28)
		Amt. water filtered	54.6 m^3	49.4 m^3	36.4 m^3
			($\bar{x}$=.41, s=.14)	($\bar{x}$=.44, s=.11)	($\bar{x}$=.45, s=.25)
				Surface	
6/2/77	Day	*Notropis atherinoides*	7 (.10)	5 (.10)	8 (.14)
		Notropis spilopterus	1 (.02)	1 (.02)	0
		Notropis volucellus	5 (.07)	5 (.10)	5 (.09)
		Dorosoma cepedianum	0	1 (.02)	1 (.02)

Table 3

Larval Fish: Source Water Sampling - Sammis Station

Date	Time	Species	#1	#2	#3
6/2/77 (cont'd)	Day	Centrarchidae	0	1 (.02)	0
		Lepomis sp.	0	0	1 (.02)
		Total #	13 (.19)	13 (.25)	15 (.27)
		Amt. water filtered	67.6 m^3	51.8 m^3	56.7 m^3
				Mid	
		Cyprinus carpio-*Carassius auratus*	0	1 (.02)	1 (.02)
		Notropis atherinoides	2 (.05)	2 (.04)	4 (.07)
		Notropis spilopterus	1 (.03)	2 (.04)	0
		Notropis volucellus	4 (.10)	3 (.05)	1 (.02)
		Clupeidae	0	1 (.02)	0
		Lepomis sp.	0	0	1 (.02)
		Total #	7 (.17)	9 (.16)	7 (.13)
		Amt. water filtered	40.5 m^3	56.2 m^3	55.3 m^3
			($\bar{x}$=.18, s=.01)	($\bar{x}$=.21, s=.06)	($\bar{x}$=.20, s=.10)
				Surface	
	Night	*Etheostoma* sp.	0	0	1 (.02)
		Cyprinus carpio-*Carassius auratus*	0	1 (.01)	2 (.04)
		Notropis atherinoides	3 (.05)	0	3 (.05)
		Notropis spilopterus	3 (.05)	6 (.07)	2 (.04)
		Notropis volucellus	0	2 (.02)	2 (.04)
		Pimephales notatus	8 (.14)	2 (.02)	1 (.02)
		Lepomis sp.	0	0	1 (.02)
		Unidentified sp.	2 (.04)	0	0
		Total #	16 (.28)	11 (.13)	12 (.22)
		Amt. water filtered	56.3 m^3	83.1 m^3	55.8 m^3

Table 3

Larval Fish: Source Water Sampling - Sammis Station

Date	Time	Species	#1	#2	#3
				Mid	
6/2/77 (cont'd)	Night	Percidae	1 (.02)	0	0
		Cyprinus carpio-*Carassius auratus*	1 (.02)	0	0
		Notropis atherinoides	1 (.02)	2 (.04)	1 (.01)
		Notropis spilopterus	16 (.34)	5 (.09)	8 (.11)
		Notropis volucellus	1 (.02)	0	3 (.04)
		Pimephales notatus	0	3 (.06)	3 (.04)
		Pomoxis sp.	0	1 (.02)	1 (.01)
		Unidentified sp.	1 (.02)	1 (.02)	2 (.03)
		Total #	21 (.45)	12 (.22)	18 (.25)
		Amt. water filtered	46.6 m^3	54.5 m^3	71.8 m^3
			($\bar{x}$=.37, s=.12)	($\bar{x}$=.18, s=.06)	($\bar{x}$=.23, s=.26)
				Surface	
6/10/77	Day	*Notropis atherinoides*	3 (.03)	13 (.11)	9 (.09)
		Notropis spilopterus	1 (.01)	0	0
		Notropis volucellus	3 (.03)	6 (.05)	5 (.05)
		Cyprinidae	2 (.02)	4 (.04)	1 (.01)
		Total #	9 (.09)	23 (.20)	15 (.16)
		Amt. water filtered	98.8 m^3	115.4 m^3	95.5 m^3
				Mid	
		Cyprinus carpio-*Carassius auratus*	1 (.01)	0	0
		Notropis atherinoides	1 (.01)	0	2 (.02)
		Notropis spilopterus	4 (.05)	0	1 (.01)
		Notropis volucellus	1 (.01)	0	3 (.03)
		Cyprinidae	0	0	1 (.01)
		Total #	7 (.08)	0	7 (.06)
		Amt. water filtered	86.9 m^3	114.2 m^3	117.2 m^3
			($\bar{x}$=.09, s=.01)	($\bar{x}$=.10, s=.14)	($\bar{x}$=.11, s=.07)

Table 3

Larval Fish: Source Water Sampling - Sammis Station

Date	Time	Species	#1	#2	#3
				Surface	
6/10/77 (cont'd)	Night	*Notropis atherinoides*	2 (.02)	8 (.07)	4 (.04)
		Notropis spilopterus	3 (.03)	23 (.20)	1 (.01)
		Notropis volucellus	1 (.01)	10 (.09)	3 (.03)
		Cyprinidae	0	4 (.04)	0
		Dorosoma cepedianum	0	0	1 (.01)
		Ictalurus natalis	0	1 (.01)	0
		Ictalurus punctatus	1 (.01)	0	0
		Ambloplites rupestris	0	1 (.01)	0
		Total #	7 (.07)	47 (.41)	9 (.10)
		Amt. water filtered	97.4 m^3	115.0 m^3	91.3 m^3
				Mid	
		Cyprinus carpio-Carassius auratus	2 (.02)	0	0
		Notropis spilopterus	2 (.02)	1 (.01)	0
		Notropis volucellus	0	1 (.01)	0
		Ictalurus natalis	0	0	1 (.01)
		Ictalurus punctatus	1 (.01)	0	1 (.01)
		Total #	5 (.06)	2 (.02)	2 (.02)
		Amt. water filtered	82.3 m^3	97.8 m^3	116.3 m^3
			($\bar{x}$=.07, s=.01)	($\bar{x}$=.22, s=.28)	($\bar{x}$=.06, s=.06)
				Surface	
6/18/77	Day	*Notropis atherinoides*	4 (.06)	0	5 (.06)
		Notropis volucellus	1 (.01)	0	0
		Clupeidae	0	0	1 (.01)
		Total #	5 (.07)	0	6 (.07)
		Amt. water filtered	71.8 m^3	88.0 m^3	80.6 m^3

Table 3

Larval Fish: Source Water Sampling - Sammis Station

Date	Time	Species	#1	#2	#3
				Mid	
6/18/77 (cont'd)	Day	*Cyprinus carpio-Carassius auratus*	0	1 (.01)	0
		Notropis atherinoides	0	1 (.01)	1 (.01)
		Notropis spilopterus	1 (.03)	0	1 (.01)
		Notropis sp.	0	0	1 (.01)
		Clupeidae	0	2 (.02)	0
		Total #	1 (.03)	4 (.04)	3 (.03)
		Amt. water filtered	33.4 m^3	100.6 m^3	106.7 m^3
			($\bar{x}$=.05, s=.03)	($\bar{x}$=.02, s=.03)	($\bar{x}$=.05, s=.03)
				Surface	
	Night	*Notropis atherinoides*	1 (.02)	4 (.05)	3 (.05)
		Notropis spilopterus	2 (.03)	2 (.02)	3 (.05)
		Notropis volucellus	0	7 (.08)	0
		Notropis sp.	1 (.02)	0	1 (.02)
		Ictalurus punctatus	0	1 (.01)	0
		Total #	4 (.06)	16 (.18)	7 (.11)
		Amt. water filtered	67.5 m^3	88.6 m^3	67.0 m^3
				Mid	
		Perca flavescens	0	1 (.01)	1 (.01)
		Notropis atherinoides	4 (.24)	0	1 (.01)
		Notropis sp.	0	0	1 (.01)
		Pimephales notatus	3 (.18)	1 (.01)	0
		Cyprinidae	0	1 (.01)	0
		Ictalurus punctatus	2 (.12)	0	0
		Total #	9 (.55)	3 (.03)	3 (.03)
		Amt. water filtered	16.4 m^3	104.1 m^3	96.1 m^3
			($\bar{x}$=.30, s=.35)	($\bar{x}$=.11, s=.11)	($\bar{x}$=.07, s=.05)

Table 3

Larval Fish: Source Water Sampling - Sammis Station

Date	Time	Species	#1	#2	#3
				Surface	
7/4/77	Day	*Notropis atherinoides*	4 (.05)	5 (.07)	59 (.65)
		Notropis spilopterus	0	0	1 (.01)
		Notropis volucellus	2 (.03)	2 (.03)	17 (.19)
		Lepomis sp.	1 (.01)	0	0
		Total #	7 (.09)	7 (.10)	77 (.84)
		Amt. water filtered	75.4 m^3	69.8 m^3	91.3 m^3
				Mid	
		Notropis atherinoides	0	3 (.05)	5 (.09)
		Notropis volucellus	1 (.03)	1 (.02)	4 (.07)
		Unidentified sp.	0	0	3 (.05)
		Total #	1 (.03)	4 (.07)	12 (.21)
		Amt. water filtered	30.2 m^3	59.5 m^3	58.3 m^3
			($\bar{x}$=.06, s=.04)	($\bar{x}$=.08, s=.02)	($\bar{x}$=.53, s=.45)
				Surface	
	Night	*Notropis atherinoides*	0	6 (.09)	8 (.11)
		Notropis spilopterus	0	5 (.08)	1 (.01)
		Notropis volucellus	0	1 (.02)	5 (.07)
		Notropis sp.	0	0	1 (.01)
		Lepomis sp.	0	2 (.03)	2 (.03)
		Total #	0	14 (.21)	17 (.23)
		Amt. water filtered	47.3 m^3	67.1 m^3	73.8 m^3
				Mid	
		Cyprinus carpio-Carassius auratus	1 (.02)	0	0
		Notropis atherinoides	2 (.04)	4 (.10)	6 (.09)

Table 3

Larval Fish: Source Water Sampling - Sammis Station

Date	Time	Species	#1	#2	#3
7/4/77 (cont'd)	Night	*Notropis spilopterus*	0	1 (.02)	2 (.03)
		Notropis volucellus	1 (.02)	9 (.22)	1 (.02)
		Total #	4 (.08)	14 (.34)	9 (.14)
		Amt. water filtered	48.5 m^3	41.0 m^3	64.3 m^3
			($\bar{x}$=.04, s=.06)	($\bar{x}$=.28, s=.09)	($\bar{x}$=.19, s=.06)
				Surface	
7/21/77	Day	*Notropis atherinoides*	30 (.47)	2 (.03)	44 (.50)
		Notropis spilopterus	0	0	1 (.01)
		Notropis volucellus	18 (.28)	0	12 (.14)
		Notropis sp.	0	1 (.02)	1
		Pimephales notatus	4 (.06)	2 (.03)	0
		Total #	52 (.82)	5 (.08)	57 (.65)
		Amt. water filtered	63.3 m^3	62.5 m^3	88.0 m^3
				Mid	
		Notropis atherinoides	1 (.02)	2 (.02)	0
		Notropis spilopterus	0	1 (.01)	0
		Notropis volucellus	1 (.02)	1 (.01)	0
		Pimephales notatus	0	1 (.01)	0
		Total #	2 (.05)	5 (.06)	0
		Amt. water filtered	42.6 m^3	82.9 m^3	84.5 m^3
			($\bar{x}$=.44, s=.55)	($\bar{x}$=.07, s=.01)	($\bar{x}$=.32, s=.46)
				Surface	
	Night	*Notropis atherinoides*	46 (.59)	1 (.02)	3 (.04)
		Notropis spilopterus	2 (.03)	0	1 (.01)
		Notropis volucellus	3 (.04)	0	0
		Pimephales notatus	0	0	1 (.01)

Table 3

Larval Fish: Source Water Sampling - Sammis Station

Date	Time	Species	#1	#2	#3
				Surface	
6/10/77 (cont'd)	Night	Notropis atherinoides	2 (.02)	8 (.07)	4 (.04)
		Notropis spilopterus	3 (.03)	23 (.20)	1 (.01)
		Notropis volucellus	1 (.01)	10 (.09)	3 (.03)
		Cyprinidae	0	4 (.04)	0
		Dorosoma cepedianum	0	0	1 (.01)
		Ictalurus natalis	0	1 (.01)	0
		Ictalurus punctatus	1 (.01)	0	0
		Ambloplites rupestris	0	1 (.01)	0
		Total #	7 (.07)	47 (.41)	9 (.10)
		Amt. water filtered	97.4 m^3	115.0 m^3	91.3 m^3
				Mid	
		Cyprinus carpio-Carassius auratus	2 (.02)	0	0
		Notropis spilopterus	2 (.02)	1 (.01)	0
		Notropis volucellus	0	1 (.01)	0
		Ictalurus natalis	0	0	1 (.01)
		Ictalurus punctatus	1 (.01)	0	1 (.01)
		Total #	5 (.06)	2 (.02)	2 (.02)
		Amt. water filtered	82.3 m^3	97.8 m^3	116.3 m^3
			($\bar{x}$=.07, s=.01)	($\bar{x}$=.22, s=.28)	($\bar{x}$=.06, s=.06)
				Surface	
6/18/77	Day	Notropis atherinoides	4 (.06)	0	5 (.06)
		Notropis volucellus	1 (.01)	0	0
		Clupeidae	0	0	1 (.01)
		Total #	5 (.07)	0	6 (.07)
		Amt. water filtered	71.8 m^3	88.0 m^3	80.6 m^3

Table 3

Larval Fish: Source Water Sampling - Sammis Station

Date	Time	Species	#1	#2	#3
				Mid	
6/18/77 (cont'd)	Day	*Cyprinus carpio*-*Carassius auratus*	0	1 (.01)	0
		Notropis atherinoides	0	1 (.01)	1 (.01)
		Notropis spilopterus	1 (.03)	0	1 (.01)
		Notropis sp.	0	0	1 (.01)
		Clupeidae	0	2 (.02)	0
		Total #	1 (.03)	4 (.04)	3 (.03)
		Amt. water filtered	33.4 m^3	100.6 m^3	106.7 m^3
			($\bar{x}$=.05, s=.03)	($\bar{x}$=.02, s=.03)	($\bar{x}$=.05, s=.03)
				Surface	
	Night	*Notropis atherinoides*	1 (.02)	4 (.05)	3 (.05)
		Notropis spilopterus	2 (.03)	2 (.02)	3 (.05)
		Notropis volucellus	0	7 (.08)	0
		Notropis sp.	1 (.02)	0	1 (.02)
		Ictalurus punctatus	0	1 (.01)	0
		Total #	4 (.06)	16 (.18)	7 (.11)
		Amt. water filtered	67.5 m^3	88.6 m^3	67.0 m^3
				Mid	
		Perca flavescens	0	1 (.01)	1 (.01)
		Notropis atherinoides	4 (.24)	0	1 (.01)
		Notropis sp.	0	0	1 (.01)
		Pimephales notatus	3 (.18)	1 (.01)	0
		Cyprinidae	0	1 (.01)	0
		Ictalurus punctatus	2 (.12)	0	0
		Total #	9 (.55)	3 (.03)	3 (.03)
		Amt. water filtered	16.4 m^3	104.1 m^3	96.1 m^3
			($\bar{x}$=.30, s=.35)	($\bar{x}$=.11, s=.11)	($\bar{x}$=.07, s=.05)

Table 3

Larval Fish: Source Water Sampling - Sammis Station

Date	Time	Species	#1	#2	#3
				Mid	
8/6/77 (cont'd)	Night	*Pimephales notatus*	1 (.03)	0	0
		Total #	1 (.03)	0	0
		Amt. water filtered	39.7 m^3	98.5 m^3	76.7 m^3
			($\bar{x}$=.01, s=.02)	($\bar{x}$=.01, s=.01)	($\bar{x}$=.01, s=.01)
				Surface	
8/22/77	Day	Total #	0	0	0
		Amt. water filtered	97.5 m^3	71.1 m^3	58.7 m^3
				Mid	
		Total #	0	0	0
		Amt. water filtered	20.6 m^3	53.8 m^3	52.9 m^3
				Surface	
	Night	*Notropis* sp.	0	1 (.01)	0
		Total #	0	1 (.01)	0
		Amt. water filtered	89.7 m^3	92.3 m^3	85.5 m^3
				Mid	
		Total #	0	0	0
		Amt. water filtered	54.7 m^3	67.4 m^3	61.2 m^3
				($\bar{x}$=.01, s=.01)	

Table 4

Fish Eggs: Day-Night Entrainment - Sammis Station
Numbers and Calculated Density (no./m^3) by Sampling Date

Date	Volume Filtered and Number of Eggs	Day #1	Day #2	Night #1	Night #2
4/15/77	Total #	2 (.01)	22 (.17)	0	0
	Amt. water filtered	138.7 m^3	132.7 m^3	132.7 m^3	132.7 m^3
5/21/77	Total #	0	1 (.01)	2 (.01)	1 (.01)
	Amt. water filtered	132.7 m^3	121.3 m^3	157.5 m^3	170.8 m^3
5/25/77	Total #	3 (.02)	5 (.03)	0	0
	Amt. water filtered	164.1 m^3	170.8 m^3	170.8 m^3	177.7 m^3
5/29/77	Total #	4 (.02)	1 (.01)	91 (.58)	6 (.04)
	Amt. water filtered	170.8 m^3	157.5 m^3	157.5 m^3	157.5 m^3
6/2/77	Total #	1 (.01)	5 (.03)	0	0
	Amt. water filtered	157.5 m^3	157.5 m^3	170.8 m^3	177.7 m^3
6/6/77	Total #	0	0	22 (.15)	0
	Amt. water filtered	144.8 m^3	144.8 m^3	144.8 m^3	144.8 m^3
6/22/77	Total #	0	0	23 (.15)	0
	Amt. water filtered	157.5 m^3	157.5 m^3	157.5 m^3	157.5 m^3
6/26/77	Total #	0	1 (.01)	22 (.13)	0
	Amt. water filtered	177.8 m^3	170.9 m^3	164.1 m^3	157.5 m^3
6/30/77	Total #	0	0	9 (.05)	7 (.04)
	Amt. water filtered	170.9 m^3	170.9 m^3	170.9 m^3	170.9 m^3
7/4/77	Total #	0	0	2 (.01)	1 (.01)
	Amt. water filtered	144.8 m^3	157.5 m^3	144.8 m^3	144.8 m^3

Table 5

Fish Eggs: Crepuscular Entrainment - Sammis Station
Numbers and Calculated Density (no./m^3) by Sampling Date

Date	Volume Filtered and Number of Eggs	Evening #1	Morning #2
4/15/77	Total #	1 (.01)	0
	Amt. water filtered	132.7 m^3	132.7 m^3
5/17/77	Total #	0	3 (.02)
	Amt. water filtered	184.8 m^3	184.8 m^3
5/25/77	Total #	12 (.07)	0
	Amt. water filtered	170.8 m^3	184.8 m^3
6/10/77	Total #	2 (.02)	0
	Amt. water filtered	132.7 m^3	132.7 m^3
6/18/77	Total #	3 (.02)	0
	Amt. water filtered	157.5 m^3	157.5 m^3
6/26/77	Total #	68 (.43)	0
	Amt. water filtered	157.5 m^3	157.5 m^3
7/4/77	Total #	172 (1.14)	0
	Amt. water filtered	151.1 m^3	144.8 m^3

Missing Pg 77

Table 6

Fish Eggs: Source Water Sampling - Sammis Station

Date	Time	Volume Filtered and Number of Eggs	#1	#2	#3
				Surface	
7/21/77	Night	Total #	12 (.16)	0	0
		Amt. water filtered	77.6 m^3	55.5 m^3	69.3 m^3

Table 7

Juvenile Fish: Day-Night Entrainment - Sammis Station
Numbers, Species Composition and Calculated Density (no./m^3) by Sampling Date
($\bar{x}$ = mean, s = standard deviation)

Date	Species	Day #1	Day #2	Night #1	Night #2
5/17/77	*Notropis hudsonius*	1 (.005)	0	0	0
	Total #	1 (.005)	0	0	0
	Amt. water filtered	184.8 m^3	184.8 m^3	184.8 m^3	184.8 m^3
		($\bar{x}$=.003, s=.004)			
5/21/77	*Notropis atherinoides*	0	0	1 (.01)	0
	Total #	0	0	1 (.01)	0
	Amt. water filtered	132.7 m^3	121.3 m^3	157.5 m^3	170.8 m^3
				($\bar{x}$=.003, s=.004)	
5/25/77	*Notropis atherinoides*	0	0	0	1 (.01)
	Total #	0	0	0	1 (.01)
	Amt. water filtered	164.1 m^3	170.8 m^3	170.8 m^3	177.7 m^3
				($\bar{x}$=.003, s=.004)	
6/6/77	*Notropis volucellus*	2 (.01)	0	0	0
	Total #	2 (.01)	0	0	0
	Amt. water filtered	144.8 m^3	144.8 m^3	144.8 m^3	144.8 m^3
		($\bar{x}$=.01, s=.01)			
6/18/77	*Notropis volucellus*	1 (.01)	0	0	0
	Total #	1 (.01)	0	0	0
	Amt. water filtered	157.5 m^3	157.5 m^3	157.5 m^3	157.5 m^3
		($\bar{x}$=.003, s=.004)			
7/21/77	*Notropis atherinoides*	0	0	1 (.005)	0
	Pimephales notatus	0	0	1 (.005)	0
	Total #	0	0	2 (.01)	0
	Amt. water filtered	184.9 m^3	184.9 m^3	184.9 m^3	184.9 m^3
				($\bar{x}$=.01, s=.01)	

Table 7

Juvenile Fish: Day-Night Entrainment - Sammis Station

Date	Species	Day #1	Day #2	Night #1	Night #2
7/29/77	*Perca flavescens*	2 (.01)	0	2 (.02)	0
	Total #	2 (.01)	0	2 (.02)	0
	Amt. water filtered	144.8 m^3	127.0 m^3	121.3 m^3	121.3 m^3
		($\bar{x}$=.01, s=.01)		($\bar{x}$=.01, s=.01)	
8/7/77	*Notropis atherinoides*	0	0	0	1 (.005)
	Total #	0	0	0	1 (.005)
	Amt. water filtered	199.5 m^3	199.5 m^3	199.5 m^3	199.5 m^3
				($\bar{x}$=.003, s=.004)	
8/14/77	*Pimephales notatus*	0	0	1 (.01)	0
	Total #	0	0	1 (.01)	0
	Amt. water filtered	170.9 m^3	170.9 m^3	170.9 m^3	170.9 m^3
				($\bar{x}$=.003, s=.004)	

Table 8

Juvenile Fish: Crepuscular Entrainment - Sammis Station
Numbers, Species Composition and Calculated Density (no./m^3) by Sampling Date
($\bar{x}$ = mean, s = standard deviation)

Date	Species	Evening #1	Morning #2
5/25/77	*Notropis atherinoides*	1 (.01)	0
	Notropis spilopterus	1 (.01)	0
	Total #	2 (.01)	0
	Amt. water filtered	170.8 m^3	184.8 m^3
		($\bar{x}$=.01, s=.01)	
7/21/77	*Cyprinus carpio-Carassius auratus*	1 (.005)	0
	Pimephales notatus	0	1 (.005)
	Total #	1 (.005)	1 (.005)
	Amt. water filtered	184.9 m^3	184.9 m^3
		($\bar{x}$=.005, s=.00)	
7/29/77	*Notropis volucellus*	1 (.01)	0
	Total #	1 (.01)	0
	Amt. water filtered	127.0 m^3	121.3 m^3
		($\bar{x}$=.004, s=.01)	
8/23/77	*Notropis atherinoides*	0	1 (.01)
	Total #	0	1 (.01)
	Amt. water filtered	177.8 m^3	177.8 m^3
		($\bar{x}$=.003, s=.004)	
8/30/77	*Notropis atherinoides*	0	1 (.01)
	Total #	0	1 (.01)
	Amt. water filtered	151.1 m^3	151.1 m^3
		($\bar{x}$=.004, s=.005)	

Table 9

Juvenile Fish: Source Water Sampling - Sammis Station
Numbers, Species Composition and Calculated Density (no./m^3) by Sampling Date
($\bar{x}$ = mean, s = standard deviation)

Date	Time	Species	#1	#2	#3
				Mid	
7/4/77	Night	*Ictalurus punctatus*	0	0	1 (.02)
		Total #	0	0	1 (.02)
		Amt. water filtered	48.5 m^3	41.0 m^3	64.3 m^3
					($\bar{x}$=.01, s=.01)
				Surface	
7/21/77	Night	*Perca flavescens*	0	1 (.02)	0
		Total #	0	1 (.02)	0
		Amt. water filtered	77.6 m^3	55.5 m^3	69.3 m^3
				Mid	
7/21/77	Night	*Notropis atherinoides*	1 (.02)	0	0
		Pimephales notatus	2 (.04)	0	0
		Total #	3 (.06)	0	0
		Amt. water filtered	47.8 m^3	84.2 m^3	68.0 m^3
			($\bar{x}$=.03, s=.05)	($\bar{x}$=.01, s=.01)	
				Mid	
8/6/77	Night	*Etheostoma nigrum*	1 (.03)	0	0
		Notropis volucellus	0	0	2 (.03)
		Pimephales notatus	0	0	2 (.03)
		Total #	1 (.03)	0	4 (.05)
		Amt. water filtered	39.7 m^3	98.5 m^3	76.7 m^3
			($\bar{x}$=.01, s=.02)		($\bar{x}$=.03, s=.04)
				Mid	
8/22/77	Night	*Ictalurus punctatus*	1 (.02)	0	0
		Total #	1 (.02)	0	0
		Amt. water filtered	54.7 m^3	67.4 m^3	61.2 m^3
			($\bar{x}$=.01, s=.01)		

Appendix B-4

Size Breakdown of Larval Fish and Egg Occurrence in Sammis Entrainment Samples

Date	Run	Time	Volume Filtered	<10 mm	>10 mm	Total	Eggs*	ELB*
4/7/77	1	1630-2030	123.5 m^3	-	-	0	-	-
	2	2250-0050	90.6 m^3	-	-	0	-	-
	3	0105-0305	132.7 m^3	-	-	0	-	-
	4	0455-0655	110.4 m^3	-	-	0	-	-
4/11/77	1	1300-1500	110.4 m^3	-	-	0	-	-
	2	1500-1700	110.4 m^3	-	-	0	-	-
	3	1930-2130	132.7 m^3	-	-	0	-	-
	4	2130-2330	132.7 m^3	-	-	0	-	-
4/15/77	1	1315-1515	138.7 m^3	-	-	0	-	2
	2	1520-1720	132.7 m^3	-	-	0	-	22
	3**	1807-2007	132.7 m^3	-	-	0	-	1
	4	2010-2210	132.7 m^3	-	-	0	-	-
	5	2215-0015	132.7 m^3	-	-	0	-	-
	6**	0515-0715	132.7 m^3	-	-	0	-	-
4/19/77	1	1350-1550	110.4 m^3	-	-	0	-	-
	2	1557-1757	110.4 m^3	-	-	0	-	-
	3	1949-2149	115.8 m^3	-	-	0	-	-
	4	2154-2354	115.8 m^3	-	-	0	-	-
4/23/77	1	1310-1510	95.3 m^3	-	-	0	-	-
	2	1515-1715	121.3 m^3	-	-	0	-	-
	3**	1800-2000	115.8 m^3	-	-	0	-	-
	4	2005-2205	121.3 m^3	-	-	0	-	-
	5	2210-0010	121.3 m^3	-	-	0	-	-
	6**	0515-0715	121.3 m^3	-	-	0	-	-
4/27/77	1	1330-1530	110.4 m^3	-	-	0	-	-
	2	1535-1735	110.4 m^3	2	-	2	-	-
	3	2047-2247	110.4 m^3	-	-	0	-	-
	4	2252-0052	110.4 m^3	4	-	4	-	-
5/1/77	1	1305-1505	100.2 m^3	-	-	0	-	-
	2	1510-1710	121.3 m^3	-	-	0	-	-
	3**	2011-2211	121.3 m^3	-	1	1	-	-
	4	2216-0016	121.3 m^3	-	1	1	-	-
	5	0020-0220	121.3 m^3	-	-	0	-	-
	6**	0530-0730	121.3 m^3	-	-	0	-	-

* Not included in total
** Crepuscular
ELB--Egg like bodies

Appendix B-4

Size Breakdown of Larval Fish and Egg Occurrence in Sammis Entrainment Samples

Date	Run	Time	Volume Filtered	<10 mm	>10 mm	Total	Eggs*	ELB*
5/9/77	1	1307-1507	132.7 m^3	1	1	2	-	-
	2	1511-1711	132.7 m^3	1	1	2	-	-
	3**	1957-2157	132.7 m^3	-	1	1	-	-
	4	2203-0003	132.7 m^3	-	1	1	-	-
	5	0010-0210	132.7 m^3	1	-	1	-	-
	6**	0515-0715	132.7 m^3	-	2	2	-	-
5/13/77	1	1315-1515	138.7 m^3	-	-	0	-	-
	2	1523-1723	132.7 m^3	-	-	0	-	-
	3	2058-2258	132.7 m^3	2	-	2	-	-
	4	2304-0004	132.7 m^3	2	-	2	-	-
5/17/77	1	1300-1500	184.8 m^3	-	-	0	-	-
	2	1503-1703	184.8 m^3	-	-	0	-	-
	3**	2030-2230	184.8 m^3	3	-	3	-	-
	4	2237-0037	184.8 m^3	1	-	1	-	-
	5	0053-0253	184.8 m^3	1	-	1	-	-
	6**	0516-0716	184.8 m^3	-	-	0	3	-
5/21/77	1	1407-1607	132.7 m^3	-	-	0	-	-
	2	1615-1815	121.3 m^3	5	-	5	-	-
	3	2105-2305	157.5 m^3	5	-	5	2	-
	4	2310-0110	170.8 m^3	1	-	1	-	1
5/25/77	1	1330-1530	164.1 m^3	5	-	5	-	3
	2	1537-1737	170.8 m^3	3	-	3	-	5
	3**	2024-2224	170.8 m^3	39	-	39	12	-
	4	2234-2434	170.8 m^3	8	-	8	-	-
	5	2440-0240	177.7 m^3	3	-	3	-	-
	6**	0530-0730	184.8 m^3	3	-	3	-	-
5/29/77	1	1450-1650	170.8 m^3	10	-	10	4	-
	2	1657-1857	157.5 m^3	3	-	3	1	-
	3	2114-2314	157.5 m^3	48	-	48	81	-
	4	2319-0119	157.5 m^3	43	-	43	6	-
6/2/77	1	1432-1632	157.5 m^3	19	-	19	1	-
	2	1648-1848	157.5 m^3	37	-	37	1	1
	3**	2040-2240	164.1 m^3	26	-	26	-	-
	4	2245-0048	170.8 m^3	21	-	21	-	-
	5	0050-0250	177.7 m^3	28	1	29	-	-
	6**	0530-0730	184.8 m^3	17	-	17	-	-

* Not included in total
** Crepuscular
ELB--Egg like bodies

Appendix B-4

Size Breakdown of Larval Fish and Egg Occurrence in Sammis Entrainment Samples

Date	Run	Time	Volume Filtered	<10 mm	>10 mm	Total	Eggs*	ELB*
6/6/77	1	1600-1800	144.8 m^3	15	2	17	-	-
	2	1806-2006	144.8 m^3	31	1	32	-	-
	3	2135-2335	144.8 m^3	46	-	46	22	-
	4	2345-0145	144.8 m^3	6	-	6	-	-
6/10/77	1	1527-1727	132.7 m^3	1	-	1	-	-
	2	1733-1933	132.7 m^3	3	-	3	-	-
	3**	2037-2237	132.7 m^3	9	-	9	2	-
	4	2242-0042	132.7 m^3	6	-	6	-	-
	5	0045-0245	132.7 m^3	2	6	8	-	-
	6**	0455-0655	132.7 m^3	-	5	5	-	-
6/18/77	1	1553-1753	157.5 m^3	1	1	2	-	-
	2	1800-2000	157.5 m^3	3	-	3	-	-
	3**	2032-2232	157.5 m^3	1	-	1	3	-
	4	2236-0036	157.5 m^3	2	-	2	-	-
	5	0041-0241	157.5 m^3	1	1	2	-	-
	6**	0521-0721	157.5 m^3	-	-	0	-	-
6/22/77	1	1603-1803	157.5 m^3	3	-	3	-	-
	2	1808-2008	157.5 m^3	3	-	3	-	-
	3	2150-2350	157.5 m^3	2	6	8	23	-
	4	2355-0155	157.5 m^3	5	-	5	-	-
6/26/77	1	1512-1712	177.8 m^3	-	-	0	-	-
	2	1724-1924	170.9 m^3	1	-	1	1	-
	3**	2030-2230	157.5 m^3	-	2	2	-	68
	4	2240-0040	164.1 m^3	6	8	14	22	-
	5	0045-0245	157.5 m^3	-	1	1	-	-
	6**	0505-0705	157.5 m^3	-	-	0	-	-
6/30/77	1	1525-1725	170.9 m^3	-	-	0	-	-
	2	1730-1930	170.9 m^3	2	-	2	-	-
	3	2150-2350	170.9 m^3	4	-	4	9	-
	4	2355-0155	170.9 m^3	2	1	3	7	-
7/4/77	1	1350-1550	144.8 m^3	4	-	4	-	-
	2	1557-1757	157.5 m^3	3	0	3	0	-
	3**	2100-2400	151.1 m^3	-	-	0	-	172
	4	2306-0106	144.8 m^3	6	0	6	2	-
	5	0113-0313	144.8 m^3	-	2	2	1	-
	6**	0505-0705	144.8 m^3	2	-	2	-	-

* Not included in total

** Crepuscular

ELB--Egg like bodies

Appendix B-5

Size Breakdown of Larval Fish and Egg Occurrence
in Sammis Source Water Samples

Date	Run	Time	Volume Filtered	<10 mm	>10 mm	Total	Eggs*	ELB*
4/7/77	NS	1627-1630	78.4 m^3	-	-	0	-	-
	ND	1745-1748**		-	-	0	-	-
	MS	1640-1643	54.9 m^3	-	-	0	-	-
	MF	1730-1733**		-	-	0	-	-
	FS	1657-1700**		-	-	0	-	-
	FD	1720-1723**		-	-	0	-	-
4/23/77	NS	1802-1807	143.8 m^3	-	-	0	-	-
	ND	1827-1832	179.5 m^3	-	-	0	-	-
	MS	1740-1745	111.4 m^3	-	-	0	-	-
	MD	1720-1725	230.3 m^3	-	-	0	-	-
	FS	1732-1737	136.9 m^3	-	-	0	-	-
	FD	1707-1712	232.9 m^3	-	-	0	-	-
5/9/77	NS	1640-1645	106.7 m^3	-	-	0	-	-
	ND	1612-1617	98.0 m^3	-	-	0	-	-
	MS	1631-1636	74.6 m^3	-	-	0	-	-
	MD	1600-1605	134.6 m^3	1	-	1	-	-
	FS	1622-1627	65.7 m^3	-	-	0	-	-
	FD	1550-1555	104.9 m^3	-	-	0	-	-
	NS	2301-2306	114.9 m^3	1	1	2	-	-
	ND	2217-2222	98.7 m^3	-	-	0	-	-
	MS	2251-2256	113.1 m^3	-	-	0	-	-
	MD	2206-2211	85.3 m^3	-	-	0	-	-
	FS	2241-2246	113.9 m^3	-	-	0	-	-
	FD	2228-2233	102.3 m^3	-	-	0	-	-
5/29/77	NS	1604-1609	66.0 m^3	18	-	18	-	-
	ND	1529-1534	17.2 m^3	12	1	13	-	-
	MS	1548-1553	46.0 m^3	16	-	16	-	-
	MD	1520-1525	34.6 m^3	51	-	51	-	-
	FS	1539-1544	46.0 m^3	19	-	19	-	-
	FD	1510-1515	39.9 m^3	17	-	17	-	-
	NS	2239-2244	77.8 m^3	41	-	41	-	-
	ND	2208-2213	54.6 m^3	20	-	20	32	-
	MS	2229-2234	46.5 m^3	26	-	26	-	-
	MD	2159-2204	49.4 m^3	16	-	16	-	-
	FS	2219-2224	73.1 m^3	45	-	45	-	-
	FD	2151-2156	36.4 m^3	9	-	9	-	-

* Not included in total
** See anomalies
ELB--Egg like bodies

NS--near station, surface
ND--near station, deep
MS--mid station, surface
MD--mid station, deep
FS--far station, surface
FD--far station, deep

Appendix B-5

Size Breakdown of Larval Fish and Egg Occurrence in Sammis Source Water Samples

Date	Run	Time	Volume Filtered	<10 mm	>10 mm	Total	Eggs*	ELB*
6/2/77	NS	1711-1716	67.6 m^3	16	-	16	-	-
	ND	1701-1706	40.5 m^3	7	-	7	-	-
	MS	1720-1725	51.8 m^3	10	-	10	-	-
	MD	1652-1657	56.2 m^3	6	-	6	-	-
	FS	1730-1735	56.7 m^3	10	-	10	-	-
	FD	1642-1647	55.3 m^3	8	-	8	-	-
	NS	0236-0241	56.3 m^3	15	-	15	-	-
	ND	0228-0233	46.6 m^3	17	-	17	1	-
	MS	0316-0321	83.1 m^3	11	-	11	-	-
	MD	0220-0225	54.5 m^3	23	-	23	-	-
	FS	0319-0324	55.8 m^3	12	1	13	-	-
	FD	0004-0009	71.8 m^3	16	-	16	-	-
6/10/77	NS	1740-1745	98.8 m^3	9	-	9	-	-
	ND	1715-1720	86.9 m^3	7	-	7	-	-
	MS	1732-1737	115.4 m^3	27	-	27	-	-
	MD	1705-1710	114.2 m^3					
	FS	1723-1728	95.5 m^3	15	-	15	-	-
	FD	1652-1657	117.2 m^3	7	-	7	-	-
	NS	0107-0112	97.4 m^3	7	-	7	-	-
	ND	2334-2339	82.3 m^3	5	-	5	-	-
	MS	2355-2400	115.0 m^3	49	2	51	-	-
	MD	2324-2329	97.8 m^3	2	-	2	1	-
	FS	2345-2350	91.3 m^3	11	-	11	-	-
	FD	2313-2318	116.3 m^3	3	-	3	-	-
6/18/77	NS	1734-1739	71.8 m^3	5	-	5	-	-
	ND	1701-1706	33.4 m^3	1	-	1**	-	-
	MS	1743-1748	88.0 m^3	-	-	0**	-	-
	MD	1712-1717	100.6 m^3	3	1	4	-	-
	FS	1755-1800	80.6 m^3	6	-	6	-	-
	FD	1723-1728	106.7 m^3	3	-	3	-	-
	NS	2330-2335	67.5 m^3	4	-	4	-	-
	ND	2253-2258	16.4 m^3	4	5	9	1	-
	MS	2340-2345	88.6 m^3	14	1	15	-	-
	MD	2305-2345	104.1 m^3	3	-	3	-	-
	FS	2350-2355	67.0 m^3	22	-	22	-	-
	FD	2317-2322	96.1 m^3	2	1	3	-	-

* Not included in total
** See anomalies
ELB--Egg like bodies

NS--near station, surface
ND--near station, deep
MS--mid station, surface
MD--mid station, deep
FS--far station, surface
FD--far station, deep

Appendix B-5

Size Breakdown of Larval Fish and Egg Occurrence in Sammis Source Water Sampling

Date	Run	Time	Volume Filtered	<10 mm	>10 mm	Total	Eggs*	ELB*
7/4/77	NS	1543-1548	75.4 m^3	6	1	7	-	-
	ND	1514-1519	30.2 m^3	1	-	1	-	-
	MS	1532-1537	69.8 m^3	7	-	7	-	-
	MD	1503-1508	59.5 m^3	4	-	4	-	-
	FS	1519-1524	91.3 m^3	77	-	77	-	-
	FD	1454-1459	58.3 m^3	12	-	12	-	-
	NS	-	47.3 m^3	-	-	0	-	-
	ND	2310-2315	48.5 m^3	4	-	4	-	-
	MS	2335-2340	67.1 m^3	14	-	14	-	-
	MD	2300-2305	41.0 m^3	14	-	14	-	-
	FS	2320-2325	73.8 m^3	17	-	17	-	-
	FD	2243-2248	64.3 m^3	7	2	9	-	-
7/21/77	NS	1537-1542	63.3 m^3	52	-	52	-	-
	ND	1528-1533	42.6 m^3	2	-	2	-	-
	MS	1546-1551	62.5 m^3	5	-	5	-	-
	MD	1519-1524	82.9 m^3	5	-	5	-	-
	FS	1555-1600	88.0 m^3	57	-	57	-	-
	FD	1509-1514	84.5 m^3	-	-	0	-	-
	NS	0025-0030	77.6 m^3	53	-	53	12	-
	ND	2326-2331	47.8 m^3	15	-	15	-	-
	MS	0012-0017	55.5 m^3	1	-	1	-	-
	MD	2337-2342	84.2 m^3	-	-	0	-	-
	FS	0001-0006	69.3 m^3	7	-	7	-	-
	FD	2350-2355	68.0 m^3	-	-	0	-	-
8/6/77	NS	1544-1549	76.2 m^3	-	-	0	-	-
	ND	1458-1463	35.9 m^3	-	-	0	-	-
	MS	1536-1541	77.4 m^3	-	-	0	-	-
	MD	1450-1455	91.2 m^3	-	-	0	-	-
	FS	1524-1529	81.0 m^3	-	-	0	-	-
	FD	1442-1447	96.6 m^3	-	-	0	-	-
	NS	2253-2258	80.4 m^3	-	-	0	-	-
	ND	2212-2217	39.7 m^3	-	1	1	-	-
	MS	2244-2249	79.9 m^3	1	-	1	-	-
	MD	2234-2239	98.5 m^3	-	-	0	-	-
	FS	2302-2307	108.0 m^3	2	-	2	-	-
	FD	2218-2223	76.7 m^3	-	-	0	-	-

* Not included in total
ELB--Egg like bodies

NS--near station, surface
ND--near station, deep
MS--mid station, surface
MD--mid station, deep
FS--far station, surface
FD--far station, deep

Appendix B-5

Size Breakdown of Larval Fish and Egg Occurrence in Sammis Source Water Samples

Date	Run	Time	Volume Filtered	<10 mm	>10 mm	Total	Eggs*	ELB*
8/22/77	NS	1540-1545	97.5 m^3	-	-	0	-	-
	ND	1513-1518	20.6 m^3	-	-	0	-	-
	MS	1532-1537	71.1 m^3	-	-	0	-	-
	MD	1504-1509	53.8 m^3	-	-	0	-	-
	FS	1523-1528	58.7 m^3	-	-	0	-	-
	FD	1456-1501	52.9 m^3	-	-	0	-	-
	NS	2237-2242	89.7 m^3	-	-	0	-	-
	ND	2145-2150	54.7 m^3	-	-	0	-	-
	MS	2223-2228	92.3 m^3	-	-	0	-	-
	MD	2154-2159	67.4 m^3	-	-	0	-	-
	FS	2213-2218	85.5 m^3	-	-	0	-	-
	FD	2203-2208	61.2 m^3	-	-	0	-	-

* Not included in total
ELB--Egg like bodies

NS--near station, surface
ND--near station, deep
MS--mid station, surface
MD--mid station, deep
FS--far station, surface
FD--far station, deep

Appendix C

Impingement

Appendix C-1

Length - Weight Curve Calculation - Sammis Station*

Taxon	m	b	r
Gizzard shad	2.786	-10.011	.980
Emerald shiner	2.158	- 7.782	.756

* Ln - Ln transformation, x = standard length   y = weight

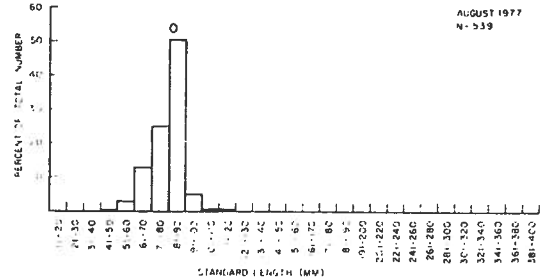
m - slope

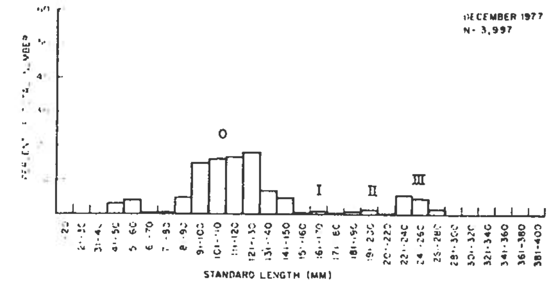
b - y intercept

r - correlation coefficient $r = \frac{m\, \sigma_x}{\sigma_y}$

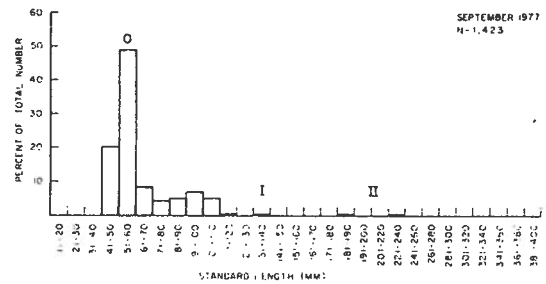
Appendix C-2 Length Frequency by Month of Five Most Abundant Fish Species Impinged - Sammis Station

APRIL 1977
N<20



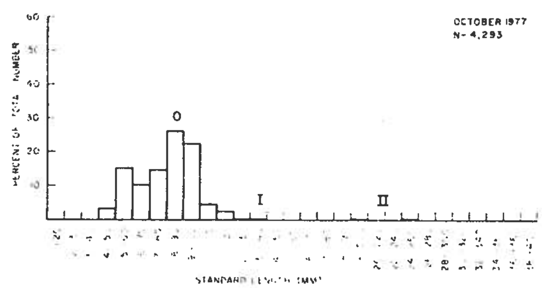


MAY 1977
N<20

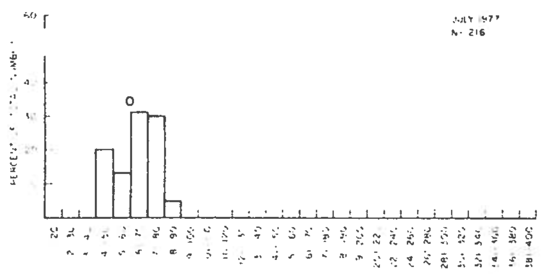


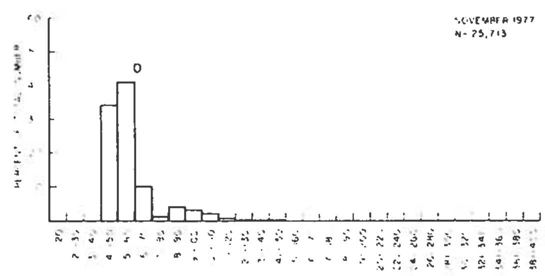
JANUARY 1978
N<20

JUNE 1977
N<20



FEBRUARY 1978
N<20





MARCH 1978
N<20

Figure 1. GIZZARD SHAD - SAMMIS STATION

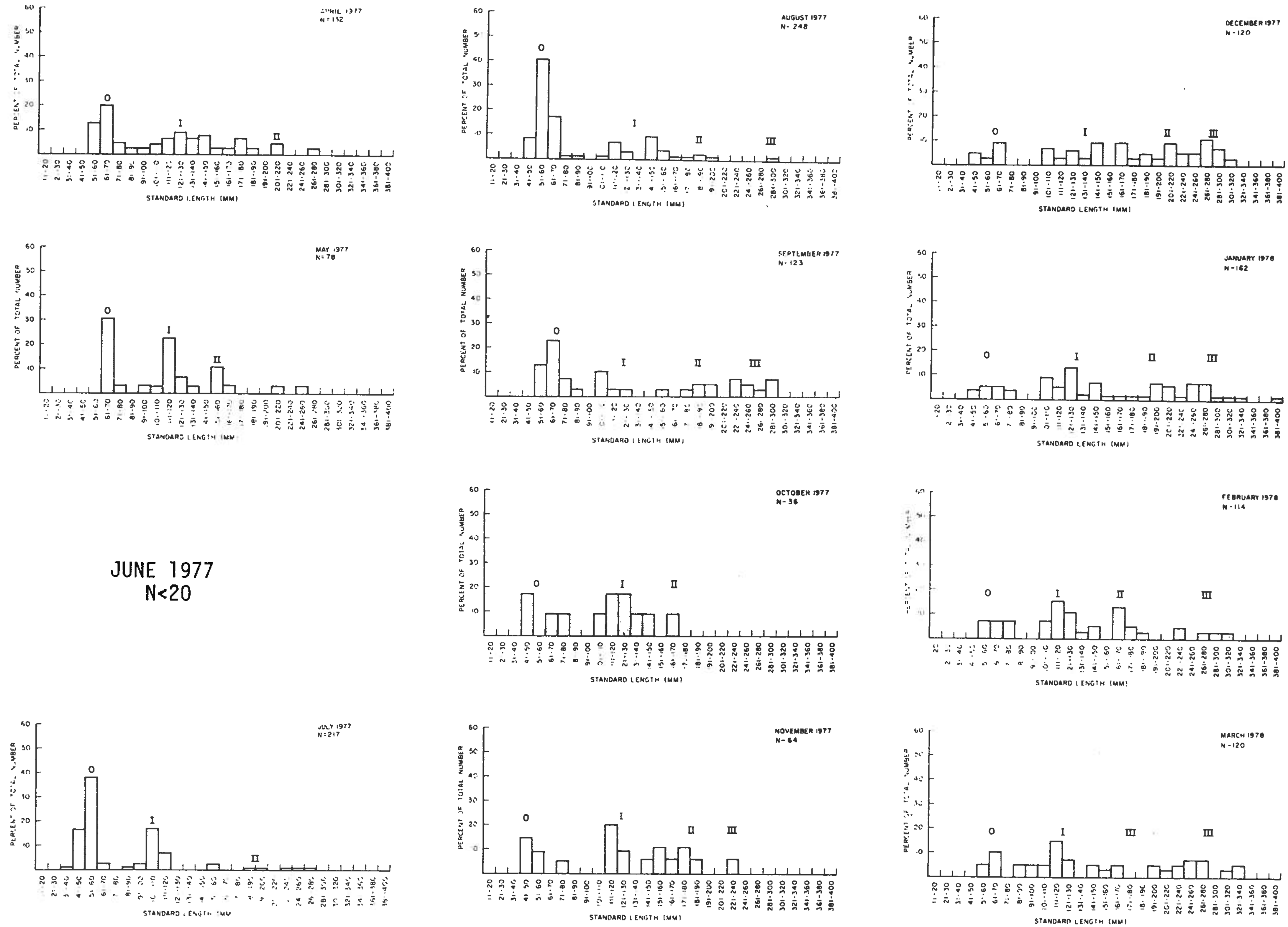


Figure 2. CHANNEL CATFISH - SAMMIS STATION

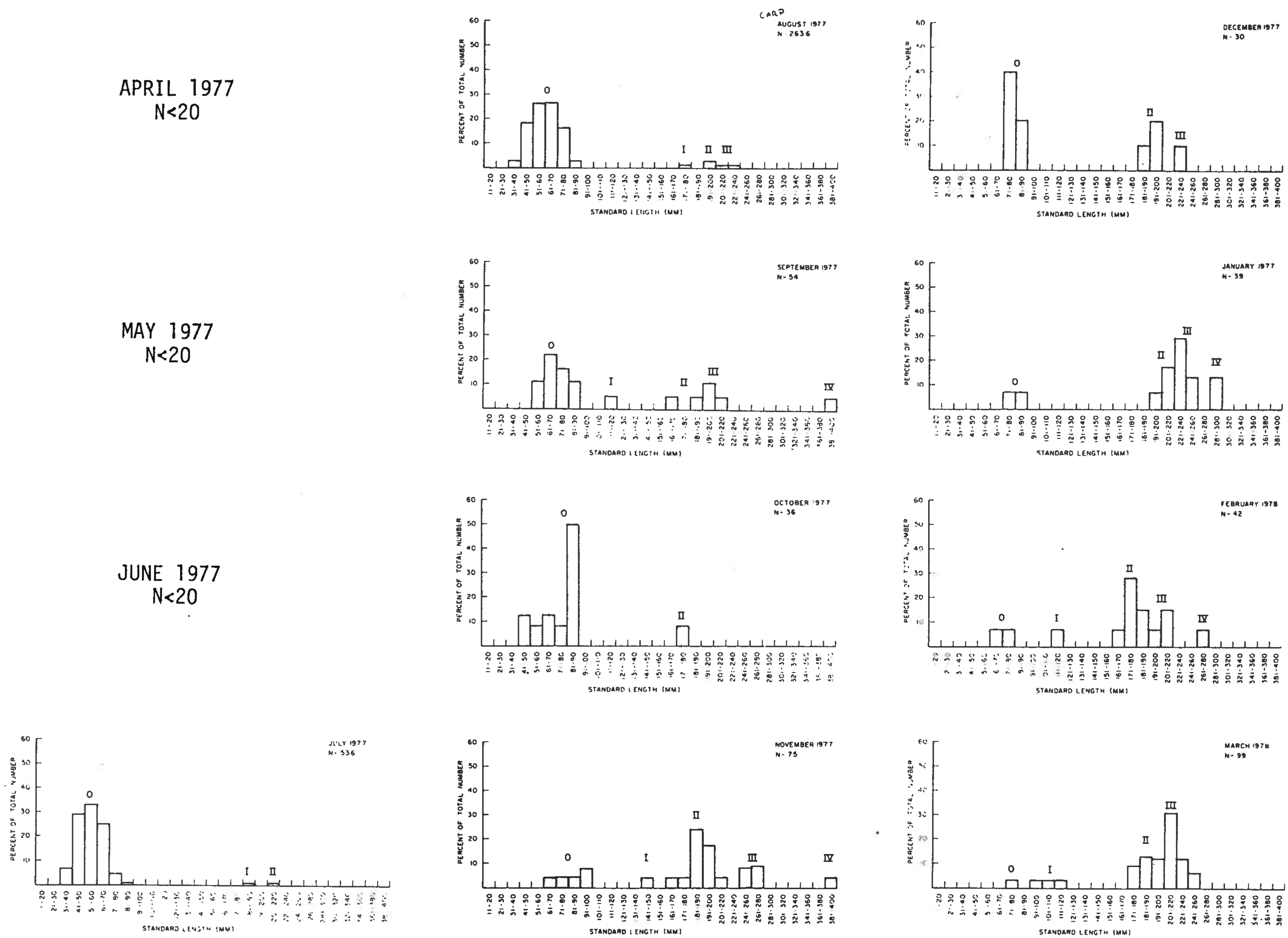


Figure 3. CARP - SAMMIS STATION

APRIL 1977
N<20

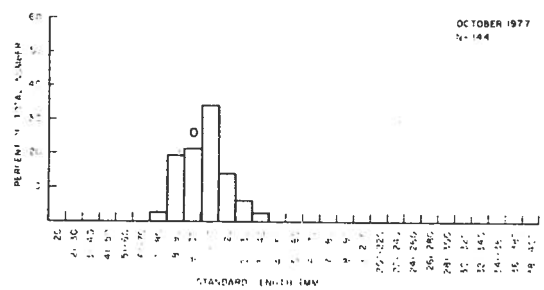
MAY 1977
N<20

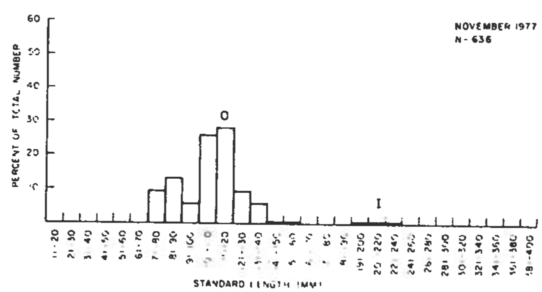
JUNE 1977
N<20

JULY 1977
N<20

AUGUST 1977
N<20

SEPTEMBER 1977
N<20





DECEMBER 1977
N<20

JANUARY 1978
N<20

FEBRUARY 1978
N<20

MARCH 1978
N<20

Figure 4. WHITE BASS - SAMMIS STATION

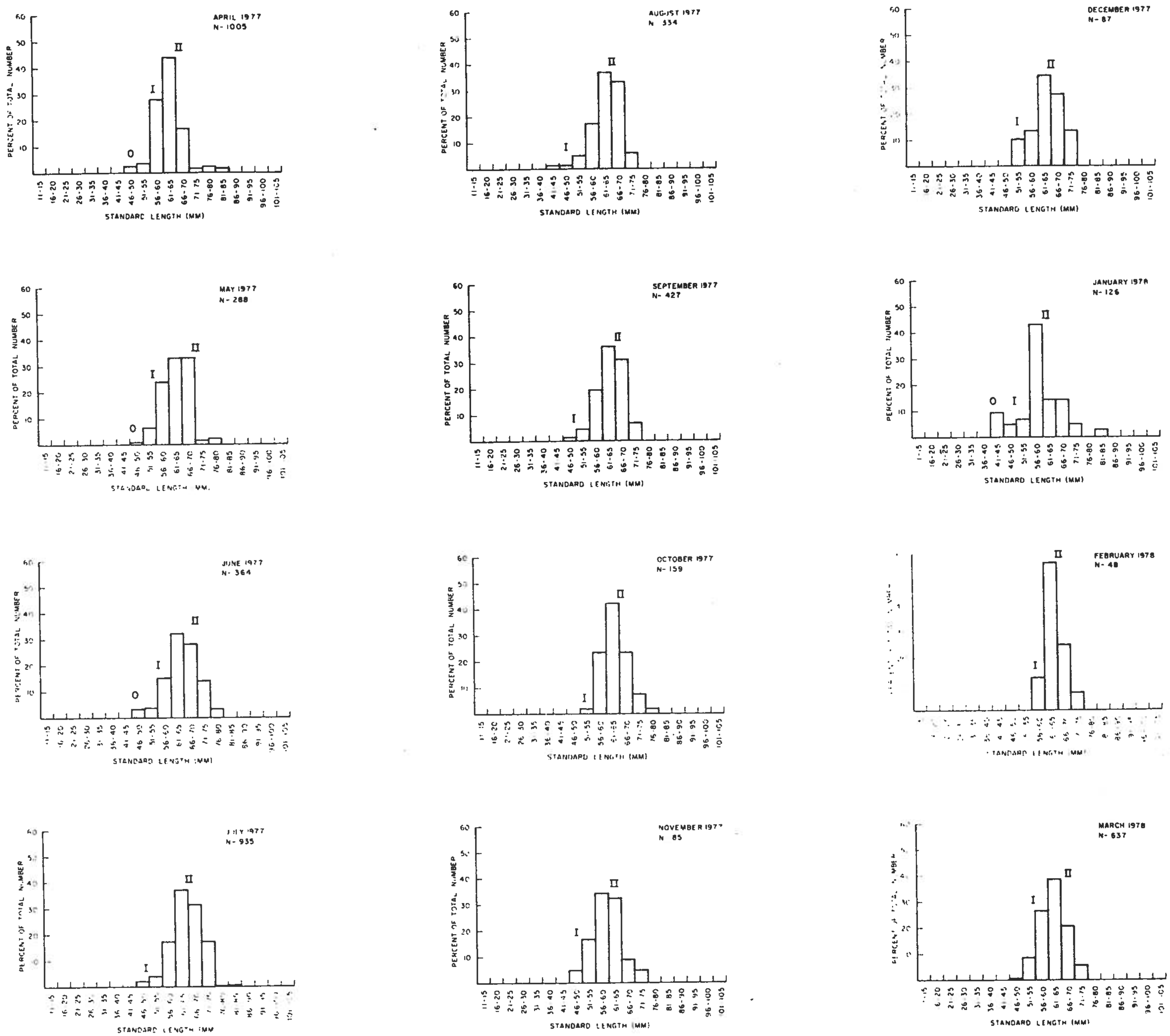


Figure 5. EMERALD SHINER - SAMMIS STATION

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
4/7/77	Emerald shiner	76	20	20	245
	White crappie	66	20	20	232
	Crayfish	40	0	12	139
	Channel catfish	40	11	11	288
	Sunfish sp.*	20	6	6	129
	Yellow perch	7	2	2	281
	Gizzard shad	3	1	1	1089
	Walleye pike	3	1	1	513
	Black bullhead	3	1	1	576
	White bass	3	1	1	73
	Common shiner	3	1	1	119
	TOTAL	264			3684
	Dead Weight				0
4/15/77	Emerald shiner	778	100	100	2583
	White crappie	84	20	20	251
	Channel catfish	50	16	15	3484
	Yellow perch	22	7	7	2400
	Bluntnose minnow	22	7	7	90
	Crayfish	22	0	7	192
	Sunfish sp.	16	4	4	703
	Black crappie	12	4	4	2456
	Log perch	12	4	4	102
	Black bullhead	9	3	3	1421
	Skipjack herring	6	2	2	56
	White bass	3	1	1	56
	Largemouth bass	3	1	1	520
	Gizzard shad	3	1	1	37
	Quillback	3	1	1	31
	Golden shiner	3	1	1	15
	Mimic shiner	3	1	1	19
	Spotfin shiner	3	1	1	19
	TOTAL	1054			14,434
	Dead weight				0

* Pumpkinseed, Bluegill and Green Sunfish are present in the April voucher collection.

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
4/23/77	Emerald shiner	150	50	0	405
	Channel catfish	42	14	7	1305
	White crappie	33	11	0	294
	Sunfish sp.*	33	11	5	1677
	Crayfish	9	0	3	69
	Log perch	6	2	2	66
	Gizzard shad	6	2	2	372
	Yellow perch	6	2	2	1011
	Carp	3	1	1	1464
	Golden redhorse	3	1	1	1149
	Bluntnose minnow	3	1	0	18
	Golden shiner	3	1	1	24
	Spotfin shiner	3	1	1	12
	TOTAL	300			7866
	Dead weight				1705
5/1/77	Emerald shiner	159	40	38	486
	Channel catfish	33	11	7	9315
	White crappie	30	10	4	1059
	Bluegill	21	7	7	840
	Golden shiner	12	4	4	63
	Black bullhead	9	3	3	1581
	White bass	6	2	2	117
	Spotfin shiner	6	2	2	27
	Gizzard shad	3	0	0	0
	Carp	3	1	1	444
	Black crappie	3	1	1	1032
	Walleye pike	3	1	1	1836
	Trout perch	3	1	1	12
	Bluntnose minnow	3	1	1	9
	Yellow perch	3	1	1	186
	TOTAL	297			9315
	Dead weight				1312
5/9/77	Bluegill	9	3	3	186
	Emerald shiner	6	2	2	18
	Channel catfish	6	2	2	108
	Spotfin shiner	6	2	2	15

* Pumpkinseed, Bluegill and Green Sunfish are present in the April voucher collection.

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
5/9/77 (cont'd)	Sunfish sp.	3	1	1	33
	White bass	3	1	1	72
	Trout perch	3	1	1	12
	Bluntnose minnow	3	1	1	21
	TOTAL	39			465
	Dead weight				1534
5/17/77	Emerald shiner	33	10	0	111
	Channel catfish	15	5	0	471
	Bluegill	12	4	4	882
	Bluntnose minnow	12	4	4	57
	Carp	6	2	2	3513
	Warmouth	3	1	1	162
	Spotfin shiner	3	1	1	15
	Mimic shiner	3	1	1	5
	TOTAL	87			5216
	Dead weight				1361
5/25/77	Emerald shiner	90	26	0	306
	Channel catfish	24	8	0	78
	Spotfin shiner	21	7	7	42
	Mimic shiner	21	7	7	14
	Crayfish	12	0	4	33
	Carp	6	2	2	789
	Yellow perch	6	2	2	570
	Bluegill	6	2	2	222
	Bluntnose minnow	6	2	2	42
	Black crappie	3	1	1	258
	Warmouth	3	1	1	156
	Black bullhead	3	1	1	171
	Shorthead redhorse	3	1	1	30
	TOTAL	204			2633
	Dead weight				767
6/2/77	Emerald shiner	144	34	0	489
	Channel catfish	12	4	0	435
	Bluntnose minnow	9	3	3	36
	Black bullhead	6	2	2	462
	Rainbow trout	6	2	2	1536
	Bluegill	3	1	0	24

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
6/2/77 (cont'd)	Golden redhorse	3	1	1	498
	Mimic shiner	3	1	1	15
	Spotfin shiner	3	1	1	30
	N. hogsucker	3	1	1	15
	TOTAL	192			3540
	Dead weight				426
6/10/77	Emerald shiner	48	11	0	165
	Crayfish	33	0	11	132
	Black bullhead	3	1	1	1092
	Quillback	3	1	1	30
	TOTAL	87			1419
	Dead weight				<28
6/18/77	Emerald shiner	102	31	31	396
	Crayfish	33	0	11	132
	Skipjack herring	9	3	3	111
	Gizzard shad	9	3	3	99
	Carp	3	1	1	942
	White crappie	3	1	1	627
	Black bullhead	3	1	1	612
	Blue catfish	3	1	1	168
	Channel catfish	3	1	1	183
	Log perch	3	1	1	21
	Bluntnose minnow	3	1	1	27
	Spotfin shiner	3	1	1	15
	TOTAL	177			3333
	Dead weight				<28
6/26/77	Emerald shiner	72	20	20	246
	Crayfish	18	0	6	78
	Gizzard shad	6	2	2	114
	Black bullhead	6	2	2	750
	Skipjack herring	6	2	2	129
	Bluegill	6	2	2	171
	Pumpkinseed	6	2	2	117
	Bluntnose minnow	6	2	2	36
	Spotfin shiner	3	1	1	24
	TOTAL	129			1665
	Dead weight				534

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
7/4/77	Emerald shiner	48	16	16	195
	Gizzard shad	36	11	11	180
	Skipjack herring	9	3	3	126
	Bluntnose minnow	6	2	2	30
	Warmouth	3	1	1	144
	Green sunfish	3	1	1	54
	TOTAL	105			729
	Dead weight				9
7/12/77	Emerald shiner	168	52	28	612
	Channel catfish	3	1	1	6
	Bluntnose minnow	3	1	1	12
	Gizzard shad	3	1	1	9
	Spotfin shiner	3	1	1	21
	TOTAL	180			660
	Dead weight				380
7/21/77	Emerald shiner	582	100	100	1887
	Carp	411	100	100	4314
	Gizzard shad	132	20	20	753
	Skipjack herring	75	15	15	1257
	Channel catfish	51	15	15	1242
	Spotfin shiner	15	5	5	45
	Bluntnose minnow	15	4	3	81
	Crayfish	12	0	4	114
	Yellow bullhead	9	3	3	192
	Trout perch	6	2	2	36
	Bluegill	6	2	2	105
	Yellow perch	6	2	2	72
	White crappie	3	1	1	657
	Black crappie	3	1	1	9
	Largemouth bass	3	1	1	6
	Golden redhorse	3	1	1	93
	Quillback	3	1	1	12
	Spotfin shiner	3	1	1	15
	Mimic shiner	3	1	1	24
	N. hogsucker	3	1	1	15
	TOTAL	1344			10,929
	Dead weight				0

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
7/29/77	Channel catfish	162	51	51	3444
	Emerald shiner	138	41	40	429
	Carp	126	41	41	1275
	Gizzard shad	45	11	11	306
	Crayfish	18	0	6	105
	Golden redhorse	12	2	2	1020
	Yellow perch	9	3	3	27
	Skipjack herring	9	2	2	93
	Spotfin shiner	6	2	2	12
	Green sunfish	3	1	1	120
	Pumpkinseed	3	1	1	42
	Black bullhead	3	1	1	354
	White sucker	3	1	0	27
	Madtom sp.	3	1	1	12
	Warmouth	3	1	1	12
	Sunfish sp.	3	1	1	363
	TOTAL	540			7641
	Dead weight				2386
8/6/77	Emerald shiner	87	27	27	258
	Channel catfish	84	26	26	1641
	Carp	75	25	25	378
	Gizzard shad	18	6	6	114
	Crayfish	9	0	3	78
	Spotfin shiner	6	2	2	27
	Black bullhead	3	1	1	564
	Smallmouth bass	3	1	1	15
	White crappie	3	1	1	12
	Goldfish	3	1	1	309
	TOTAL	291			3396
	Dead weight				0
8/14/77	Carp	96	28	28	1611
	Gizzard shad	96	21	10	637
	Emerald shiner	87	24	11	276
	Channel catfish	78	25	11	1176
	Skipjack herring	3	1	1	285
	Largemouth bass	3	1	1	57
	Trout perch	3	1	1	27

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
8/14/77 (cont'd)	Yellow perch	3	1	1	15
	White sucker	3	1	1	21
	Spotfin shiner	3	1	1	9
	Crayfish	3	1	1	54
	TOTAL	378			4167
	Dead weight				0
8/22/77	Gizzard shad	402	124	94	3816
	Emerald shiner	87	24	0	276
	Carp	72	20	0	1359
	Skipjack herring	51	10	10	396
	Channel catfish	27	9	0	486
	Crayfish	18	0	6	60
	Bluegill	6	2	2	69
	Quillback	3	1	1	171
	Largemouth bass	3	1	1	66
	Warmouth bass	3	1	1	93
	Trout perch	3	1	1	6
	Yellow perch	3	1	1	339
	White crappie	3	1	1	21
	TOTAL	681			7158
	Dead weight				255
8/29/77	Emerald shiner	72	24	0	243
	Channel catfish	60	20	20	1458
	Gizzard shad	30	10	10	408
	Carp	21	7	7	720
	Largemouth bass	6	2	2	114
	Goldfish	3	1	1	315
	White sucker	3	1	1	21
	Black crappie	3	1	1	612
	Crayfish	3	0	0	27
	TOTAL	201			3918
	Dead weight				0
9/7/77	Emerald shiner	207	64	56	612
	Gizzard shad	39	13	13	345
	Channel catfish	33	10	11	1299

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
9/7/77 (cont'd)	Carp	15	5	5	1281
	White bass	12	4	4	114
	Skipjack herring	12	4	4	87
	Blue catfish	9	3	3	27
	Largemouth bass	9	3	3	984
	Crayfish	9	0	0	21
	Trout perch	5	1	1	9
	White sucker	3	1	1	264
	Golden redhorse	3	1	1	21
	Walleye pike	3	1	1	1089
	Yellow perch	3	1	1	663
	Bluntnose minnow	3	1	1	15
	TOTAL	363			6831
	Dead weight				1485
9/15/77	Gizzard shad	141	42	12	798
	Emerald shiner	99	32	4	339
	Channel catfish	42	14	14	3405
	Carp	18	6	6	7296
	Yellow perch	6	2	2	36
	Trout perch	6	2	2	108
	White sucker	3	1	1	21
	Skipjack herring	3	1	1	36
	White bass	3	1	1	51
	White crappie	3	1	1	417
	TOTAL	330			12,525
	Dead weight				309
9/23/77	Gizzard shad	1245	243	0	16,962
	Emerald shiner	123	40	0	390
	Channel catfish	48	15	15	2721
	Carp	21	7	7	969
	Bluntnose minnow	12	4	4	48
	Bluegill	9	3	3	378
	Golden shiner	6	2	2	102
	Largemouth bass	6	2	2	231
	Skipjack herring	6	2	2	114
	River redhorse	3	1	1	855
	Goldfish	3	1	1	648

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
9/23/77 (cont'd)	Yellow perch	3	1	1	231
	Trout perch	3	1	1	6
	White bass	3	1	1	84
	White sucker	3	1	1	15
	Shorthead redhorse	3	1	1	39
	Spotfin shiner	3	1	1	15
	TOTAL	1500			23,808
	Dead weight				0
10/1/77	Gizzard shad	1038	195	0	9117
	Emerald shiner	87	28	0	293
	Channel catfish	15	5	0	708
	White bass	12	4	0	209
	Yellow perch	12	4	4	367
	Carp	9	2	0	55
	Pumpkinseed	3	1	1	407
	White sucker	3	1	1	31
	Log perch	3	1	1	22
	Shorthead redhorse	3	1	1	37
	White crappie	3	1	1	12
	TOTAL	1188			11,258
	Dead weight				0
10/9/77	Gizzard shad	2391	203	0	30,606
	Emerald shiner	42	14	0	138
	White bass	21	7	0	660
	White crappie	21	7	7	177
	Carp	15	5	1	152
	Largemouth bass	15	5	5	1362
	Channel catfish	15	5	5	396
	White sucker	6	2	2	228
	Crayfish	6	0	2	57
	Bluegill	3	1	1	132
	Green sunfish	3	1	1	21
	Goldfish	3	1	1	738
	Bluntnose minnow	3	1	1	12
	TOTAL	2544			34,983
	Dead weight				0

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
10/17/77	Gizzard shad	1644	157	0	15,480
	White bass	111	36	0	2631
	Bluegill	33	11	11	276
	Emerald shiner	21	7	0	81
	White crappie	15	5	5	63
	Largemouth bass	12	4	4	840
	Carp	12	4	4	192
	Pumpkinseed	6	2	2	30
	Black crappie	6	2	2	438
	Channel catfish	6	2	2	129
	Brown bullhead	3	1	1	453
	Yellow bullhead	3	1	1	12
	Skipjack herring	3	1	1	738
	Crayfish	3	0	1	27
	TOTAL	1878			21,390
	Dead weight				0
10/25/77	Gizzard shad	321	106	1	2654
	Emerald shiner	9	3	0	29
	White crappie	6	2	0	28
	Bluegill	3	1	1	5
	TOTAL	339			2687
	Dead weight				0
11/1/77	Gizzard shad	22,423	200	0	16,813
	White bass	69	18	0	258
	Bluegill	23	6	6	19
	Emerald shiner	19	5	0	18
	Channel catfish	15	4	3	129
	White crappie	8	2	2	6
	Carp	8	2	2	541
	Golden shiner	4	1	1	3
	TOTAL	22,569			68,674
	Dead weight				0
11/10/77	Gizzard shad	687	217	0	4260
	White bass	51	17	8	981
	Emerald shiner	18	6	6	63
	White crappie	18	6	6	750
	Bluegill	15	5	5	348

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
11/10/77 (cont'd)	Channel catfish	9	3	3	399
	Yellow perch	3	1	1	375
	Carp	3	1	1	24
	Log perch	3	1	1	24
	Black bullhead	3	1	1	1080
	Muskellunge	3	1	1	2454
	TOTAL	813			10,758
	Dead weight				0
11/18/77	Gizzard shad	1878	200	1	23,575
	White bass	346	108	1	12,978
	Bluegill	45	14	14	397
	Emerald shiner	22	7	1	58
	Channel catfish	22	7	1	439
	White crappie	16	5	5	51
	Carp	13	4	4	525
	Black crappie	3	1	1	746
	Pumpkinseed	3	1	1	82
	Yellow perch	3	1	1	4
	Crayfish	3	0	1	15
	TOTAL	2355			38,870
	Dead weight				<28
11/26/77	Gizzard shad	726	225	0	7266
	White bass	171	57	1	7302
	Carp	51	17	12	13,088
	Emerald shiner	24	8	0	77
	Channel catfish	18	6	6	780
	Largemouth bass	12	4	4	1955
	White crappie	9	3	3	41
	Goldfish	6	2	2	2312
	Brown bullhead	6	2	2	518
	Crayfish	6	0	2	53
	Skipjack herring	3	1	1	500
	White sucker	3	1	1	605
	Bluegill	3	1	1	9
	TOTAL	1038			34,503
	Dead weight				4919

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
12/4/77	Gizzard shad	555	185	0	6636
	Emerald shiner	6	2	2	10
	Channel catfish	3	1	1	7
	White bass	3	1	1	113
	White crappie	3	1	1	14
	Bluegill	3	1	1	5
	TOTAL	573			6785
	Dead weight				0
12/12/77	Gizzard shad	3396	100	0	10,715
	Channel catfish	96	32	32	15,139
	Emerald shiner	33	11	11	101
	Black crappie	21	7	7	2243
	White crappie	12	4	4	36
	Carp	9	3	3	1363
	Spotted bass	9	3	3	733
	White bass	6	2	2	2003
	Crayfish	6	0	2	32
	Bluntnose minnow	3	1	1	8
	Sucker sp.	3	0	1	32
	Rock bass	3	1	1	8
	Bluegill	3	1	1	53
	TOTAL	3600			132,466
	Dead weight				44,155
12/20/77	Gizzard shad	27	9	9	538
	Carp	12	4	4	644
	Emerald shiner	6	2	2	23
	Bluegill	6	2	2	44
	Crayfish	6	0	2	71
	Quillback	3	1	1	1543
	White sucker	3	1	1	32
	Channel catfish	3	1	1	60
	Brown bullhead	3	1	1	211
	Spotted bass	3	1	1	292
	Pumpkinseed	3	1	1	6
	Green sunfish	3	0	0	NT
	Black crappie	3	1	1	20
	TOTAL	81			3484
	Dead weight				1215

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
12/28/77	Emerald shiner	42	14	3	131
	Gizzard shad	27	9	2	2768
	Channel catfish	18	6	6	1808
	Carp	9	3	3	518
	Black crappie	6	2	2	1151
	E. banded killifish	3	1	1	9
	Yellow bullhead	3	1	1	1435
	White bass	3	1	1	114
	Spotted bass	3	1	1	622
	Crayfish	3	0	1	24
	TOTAL	117			8580
	Dead weight				0
1/5/78	Emerald shiner	21	7	7	75
	Carp	18	6	6	4460
	Channel catfish	9	3	3	443
	Gizzard shad	6	2	2	120
	E. banded killifish	3	1	1	19
	Black crappie	3	1	1	414
	Rock bass	3	1	1	16
	TOTAL	63			5546
	Dead weight				0
1/13/78	Emerald shiner	63	21	0	164
	Channel catfish	33	14	10	6863
	Carp	15	5	5	4418
	Trout perch	3	1	1	12
	White crappie	3	1	1	274
	Yellow perch	3	1	1	5
	Freshwater drum	3	1	1	2619
	Crayfish	3	0	1	9
	TOTAL	126			14,363
	Dead weight				1385

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
1/21/78	Channel catfish	63	21	21	5732
	Emerald shiner	6	2	2	21
rare	E. banded killifish	3	1	1	10
	Crayfish	1	0	1	19
	TOTAL	75			5781
	Dead weight				157
1/30/78	Channel catfish	48	8	8	6793
	Emerald shiner	36	6	0	59
	Log perch	6	1	1	18
	Carp	6	1	1	1882
	Crayfish	6	0	1	13
	TOTAL	102			8764
	Dead weight				2970
2/6/78	Channel catfish	81	27	27	6500
	Emerald shiner	15	5	5	44
	Crayfish	12	0	4	21
	Carp	9	3	3	856
	Log perch	3	1	1	9
	TOTAL	120			7429
	Dead weight				0
2/14/78	Channel catfish	30	10	10	3122
	Emerald shiner	12	4	4	37
	Carp	9	3	3	1144
	Golden redhorse	3	1	1	65
	E. banded killifish	3	1	1	9
	Rock bass	3	1	1	7
	Pumpkinseed	3	1	1	7
	Crayfish	3	1	1	8
	TOTAL	66			4397
	Dead weight				1106
2/23/78	Carp	24	8	8	4465
	Emerald shiner	21	7	7	79
	Channel catfish	6	2	2	244

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
2/23/78 (cont'd)	Crayfish	6	2	2	31
	E. banded killifish	3	1	1	14
	White bass	3	1	1	98
	TOTAL	63			4930
	Dead weight				810
3/2/78	Emerald shiner	87	29	29	245
	Carp	51	17	17	7994
	Channel catfish	30	10	10	4144
	Golden shiner	6	2	2	34
	Black crappie	6	2	2	1736
	Crayfish	6	0	2	41
	Goldfish	3	1	1	705
	Bluntnose minnow	3	1	1	12
	Rock bass	3	1	1	6
	Pumpkinseed	3	1	1	8
	TOTAL	198			14,924
	Dead weight				748
3/10/78	Emerald shiner	33	11	11	90
	Carp	18	6	6	4419
	Channel catfish	9	3	3	384
	Yellow perch	3	1	1	97
	Sauger	3	1	1	1140
	TOTAL	66			6130
	Dead weight				9060
3/17/78	Emerald shiner	417	139	3	1089
	Channel catfish	36	12	12	3223
	Carp	24	8	8	6059
	White sucker	9	3	3	170
	Goldfish	6	2	2	2166
	Bluntnose minnow	6	2	2	35
	Trout perch	6	2	2	21
	Crayfish	6	0	2	20
	Golden shiner	3	1	1	15
	Mimic shiner	3	1	1	6
	Black crappie	3	1	1	102
	TOTAL	519			12,905
	Dead weight				0

Appendix C-3

Impingement Summary - Sammis Station

Date	Species	# Individuals (Per 24H)	Number Measured	Number Weighed	Weight (grams/24H)
3/27/78	Emerald shiner	120	40	29	325
	Channel catfish	45	15	15	4525
	Crayfish	24	0	8	108
	Carp	6	2	2	1008
	Pumpkinseed	6	2	2	10
	White sucker	3	1	1	99
	Shorthead redhorse	3	1	1	74
	Goldfish	3	1	1	779
	Golden shiner	3	1	1	13
	Mimic shiner	3	1	1	9
	Bluntnose minnow	3	1	1	20
	Brown bullhead	3	1	1	170
	Sauger	3	1	1	592
	Yellow perch	3	1	1	333
	TOTAL	228			8063
	Dead weight				35

Appendix C-4

Voucher Collection - Sammis Station

Scientific Name	Common Name
Clupeidae	Herrings
Dorosoma cepedianum	Gizzard shad
Alosa chrysochloris	Skipjack herring
Esocidae	Pikes
Esox masquinongy	Muskellunge
Cyprinidae	Minnows
Carassius auratus	Goldfish
Notemigonus crysoleucas	Golden shiner
Notropis atherinoides	Emerald shiner
Notropis cornutus	Common shiner
Notropis spilopterus	Spotfin shiner
Notropis volucellus	Mimic shiner
Pimephales notatus	Bluntnose minnow
Catostomidae	Suckers
Catostomus commersoni	White sucker
Hypentelium nigricans	Northern hogsucker
Moxostoma carinatum	River redhorse
Moxostoma erythrurum	Golden redhorse
Moxostoma macrolepidotum	Shorthead redhorse
Ictaluridae	Catfishes
Ictalurus natalis	Yellow bullhead
Ictalurus nebulosus	Brown bullhead
Ictalurus punctatus	Channel catfish
Percopsidae	Trout-Perches
Percopsis omiscomaycus	Trout-perch
Cyprinodontidae	Killifishes
Fundulus diaphanus	Banded killifish
Percichthyidae	Temperate basses
Morone chrysops	White bass
Centrarchidae	Sunfishes
Ambloplites rupestris	Rock bass
Lepomis cyanellus	Green sunfish
Lepomis gibbosus	Pumpkinseed
Lepomis gulosus	Warmouth
Lepomis macrochirus	Bluegill
Micropterus punctulatus	Spotted bass
Micropterus salmoides	Largemouth bass
Pomoxis annularis	White crappie

Appendix C-4

Voucher Collection - Sammis Station (cont'd)

Scientific Name	Common Name
Percidae	Perches
Percina caprodes	Logperch
Stizostedion canadense	Sauger
Stizostedion vitreum vitreum	Walleye

Appendix D

Background - Ohio River Fishes

Appendix D
Background - Ohio River Fishes

Gizzard shad (*Dorosoma cepedianum*)

The gizzard shad, an abundant species throughout most of the Ohio River, spawns usually in May, seeking sand or gravel in shallow water. The shad is usually an inhabitant of quiet waters, and the lock impoundments on the River favor this species.

The shad is mature at Age II, although males and some females may mature at Age I.[1] The shad grows rapidly by feeding on plankton and by skimming algae from substrate surfaces, and by Age I is usually too large to be ingested except by the largest predators.

Mimic shiner (*Notropis volucellus*)

The mimic shiner is very similar to its more commonly found relative *Notropis stramineus*. Mimic shiners occupy different habitats than the *stramineus*, preferring more open water. Along with more siltation of substrate, quiet turbid waters are more tolerated by the mimic shiner. Mimics are found schooling with emerald shiners in the Ohio River.[2] Two subspecies are found in the Ohio River drainage: *Notropis v. volucellus* and *Notropis v. wickliffi*.

Mimic shiners spawn over an extended period that usually starts in mid June and continues until late July or early August. The eggs are presumably broadcast over vegetation in up to 15-20 ft of water.[3] Mimic shiners are a forage fish. They are small and only reach an Age of II.

Spotfin shiner (*Notropis spilopterus*)

The spotfin spawns over an extended period from late spring until possibly August. The adhesive eggs are laid on the underside of submerged objects such as sticks or rocks. Probably a shoreline inhabitant of the Ohio River, it feeds on terrestrial and aquatic insects.

Bluntnose minnow (Pimephales notatus)

Spawning of this minnow may start as early as May and continue until August. Spawning occurs in very shallow water, where the eggs are deposited on the undersides of flat stones, boards, or rubble and debris. The male guards the nest site for some time afterwards.

Adult bluntnose prefer gravel or sand bottoms with some mud in the shallows of streams or creeks.[3]

Bluntnose young and adults are probably an important food for predators such as sunfish or bass that inhabit shallow water.

Channel catfish (Ictalurus punctatus)

Spawning in late spring or early summer, or at temperatures of 75-85°F, the channel catfish deposits its eggs in cavities which may be man made debris (kegs, drums, etc.) or which may be excavated by the adult males. Adults of at least 4-6 years of age can breed. The male protects the nest and eggs and cares for the yolk-sac young until they are old enough to swim away.

The Ohio River is the type of river in which channel catfish can find prime habitat. Cool deep water over sand, gravel, or rubble bottoms are largely preferred. Food of the channel catfish is very diverse, being comprised of crustaceans, insect larvae, algae, or larger water plants and other fish.[3]

The channel catfish is widely accepted as a food fish and is a common fish in the Ohio River sport fishery.

Emerald shiner (Notropis atherinoides)

Emerald shiners spawn from approximately June to mid August. Little is known of the spawning act, but the eggs seem to be scattered in open water. The nature of this species is that an open water, pelagic fish.

The emerald shiner has only three age classes. Year-to-year populations fluctuate, sometimes widely. The emerald shiner is usually the dominant cyprinid in the Ohio River.

The emerald shiner feeds on plankton and insects and is in turn fed upon by all pisciverous species. All age classes are small enough to be subject to predation by most predators. Emerald shiners are very important forage.

Carp (Cyprinus carpio) and Goldfish (Carrasius auratus)

These two species can be discussed together because they are so ecologically similar. However, the carp clearly dominates the two species in the Ohio River fauna. Both species spawn over the extended period from mid May to mid August. Eggs are adhesive and scattered in weedy shallows or over debris or rubble.[1,3]

The larvae of these two species are very similar morphologically, and with the added complication of widespread hybridization, differentiating between the two as larvae is difficult. The value of telling the two apart may only be academic.

Carp and goldfish feed on a variety of insect larvae, molluscs, worms and crustaceans. Plant material, both aquatic and terrestrial, is consumed.

Maturity is stated as being at about Age III for carp.[1]

White bass (Morone chrysops)

Sexually mature white bass move into gravel shoals or up larger tributaries to spawn, usually as the water reaches 55°F. The eggs are extended near the surface or mid depths, and sink to the bottom where they stick to the substrate. White bass grow very rapidly and are sexually mature at Age III.

White bass feed primarily on other fish. Feeding, as well as schooling, is sight dependent in the white bass, so turbid conditions are usually avoided.[3] The white bass is a popular sport fish and in some areas helps to support a commercial fishery.

Yellow perch (Perca flavescens)

Perch spawn in shallow water when water temperatures reach 44-54°F, usually from late April through May. Perch lay semi-buoyant eggs in gelatinous strings which adhere to submerged vegetation on the bottom. Male perch are sexually mature by Age III and females by Age IV. Perch often travel in schools which are size, age or sexually segregated.

Perch usually inhabit quiet waters. In larger bodies of water, they may be found in various depths near the bottom where they prefer 68°F isotherm.

When small, perch fall prey to larger predators. Large perch may feed on a variety of small fishes, but invertebrates such as insect larvae and crustaceans are important in the diet of all age classes.

The yellow perch is sought after as a food and sport fish.

References

[1]Carlander, K.D. 1969. Handbook of Freshwater Fisheries Biology. Iowa State University Press, Ames, Iowa. Vol. I. 752 pp.

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[3]Scott, W.B. and E.J. Crossman. 1973. Freshwater Fishes of Canada. Jour. Fish. Res. Board Can. 966 pp.